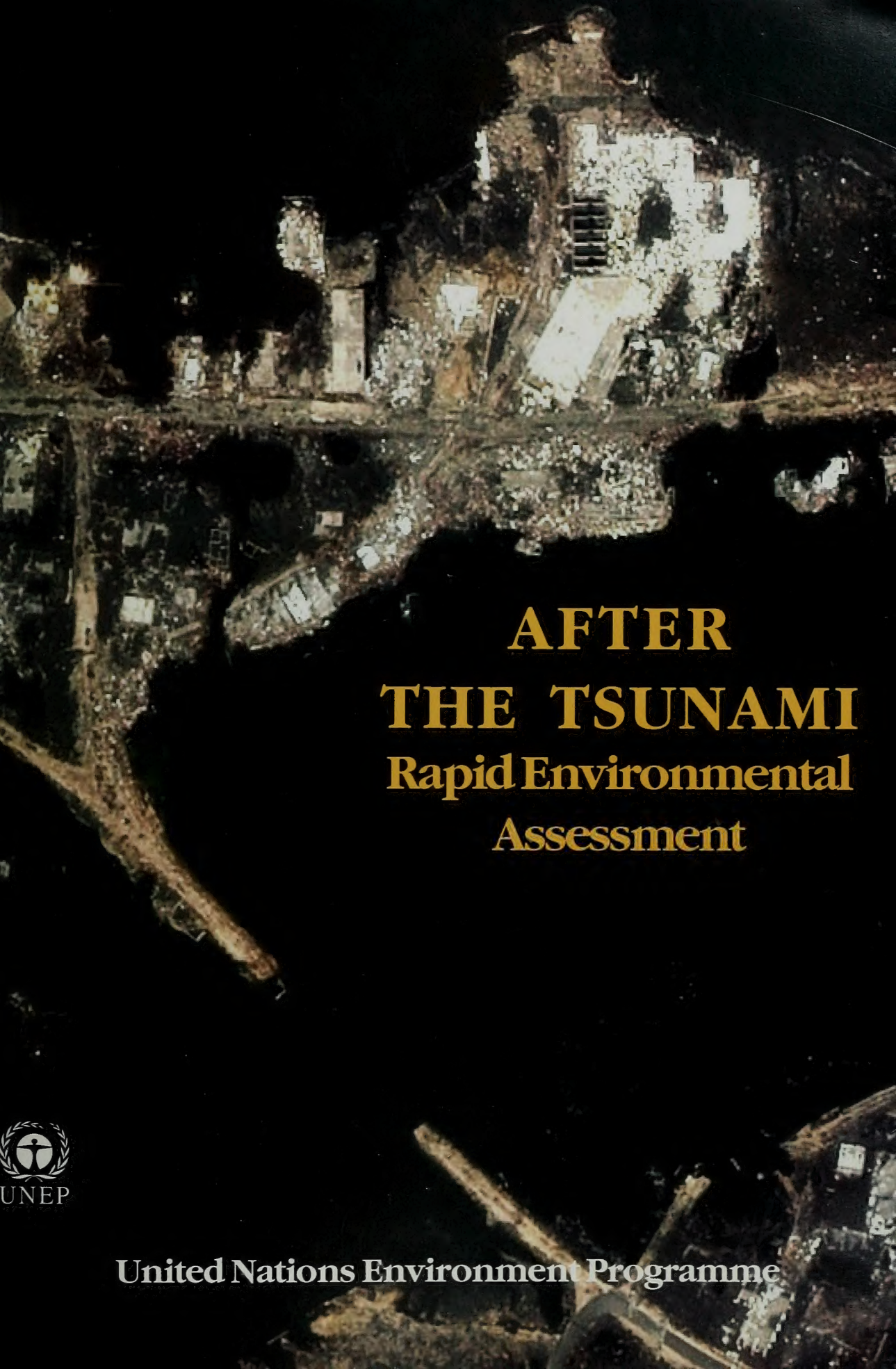


AFTER THE TSUNAMI

Rapid Environmental Assessment

UNEP

United Nations Environment Programme

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The devastated shoreline of Banda Aceh town, on the Indonesian Island of Sumatra (28 December 2004). The massive earthquake off the coast of Sumatra on 26 December 2004 triggered a tsunami that claimed the lives of more than 200,000 people. The vast majority of the victims lived in Aceh Province, but the impact of the tsunami reached as far as the coast of Africa. Around the Indian Ocean, coastal communities have been faced with the challenges of rebuilding shattered lives. As part of the immediate humanitarian response, the United Nations Environment Programme (UNEP) has been working to assess the environmental damage caused by the Asian tsunami, and its implications for the farmers, fishermen and workers in the region's tourist industry who all depend so heavily on the natural world for their livelihoods and well-being.

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Rapid Environmental Assessment

United Nations Environment Programme

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Maruthamunai, Sri Lanka. Minhaz Haque, aged 15, stands in the rain near his destroyed house in Maruthamunai village, eastern Sri Lanka. He says there is nothing left, not even the foundation, as if the house was never there. © Shehzad Noorani/Still Pictures

"...there is nothing left,
not even the foundation,
as if the house was never there..."

FOREWORD

by Klaus Toepfer
Executive Director UNEP



Although several weeks have passed since the Asian tsunami devastated coastal communities in 12 countries around the Indian Ocean, we are still struggling to comprehend the magnitude of the human losses. The suffering and destruction that was left in the tsunami's wake have prompted an unprecedented global response. Determined and resilient local communities, with help from national and international organizations and governments, have mobilized relief and started recovery. Now, as attention turns to reconstruction, the focus has changed to look at the underlying issues and plan for sustainable re-development.

UNEP's mission in this context is clear: to provide and coordinate environmental expertise that can rapidly assess the extent of damage to ecosystems and environmental infrastructure; to identify, and bring to the international community's immediate attention, urgent environmental risks; and to ensure that the environment is fully integrated into the region's reconstruction and development agenda. In a part of the world where tourism, fisheries and agriculture form the economic base, the protection of ecosystems and the sound management of natural resources are crucial to the region's development. With care for the environment, reconstruction efforts can reduce future risks from natural disasters and provide lasting benefit to the people of the region.

To carry out this mission and to harness UNEP's technical resource base, UNEP created the Asian Tsunami Disaster Task Force, which began operations on 28 December 2004. The Task Force has particularly benefited from the support of the UNEP Regional Office for Asia Pacific. UNEP has fielded experts to Indonesia, Thailand, Sri Lanka, Maldives, Yemen and Seychelles to assess the tsunami's impact on the environment. We are also aware that India, Malaysia and Myanmar are conducting their own assessments, and we are grateful to the Government of India for already sharing their results with us.

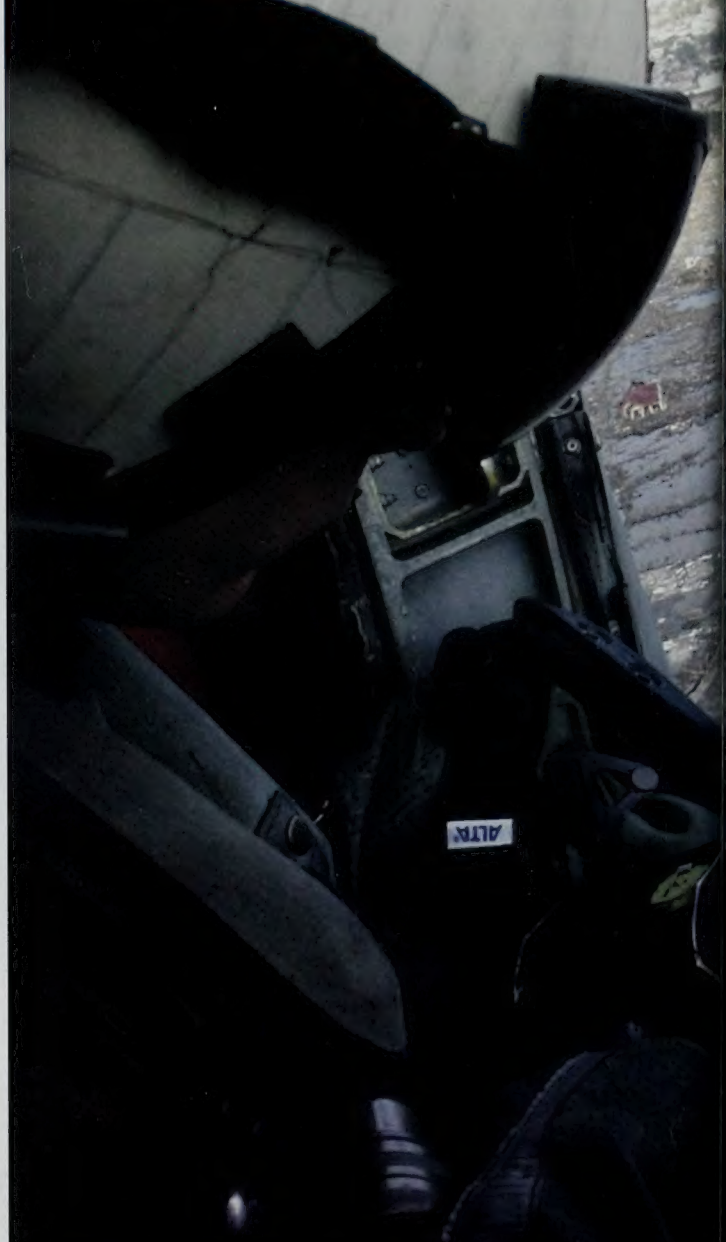
This report is the product of close cooperation between UNEP and national environmental authorities and experts. It provides a preliminary ground-level look at the tsunami's impact on various sectors of the region's environment. It highlights problems in need of immediate attention, underscoring the strong link between environment and sustainable livelihood and the need for improved early warning and disaster preparedness systems.

The report benefits from and complements the work and findings of numerous needs assessments and other assessments by individuals, international and national organizations and specialized institutions. IUCN and WWF have provided valuable support to the UNEP Task Force, and United Nations colleagues in the affected countries—including representatives of OCHA, UNDP, HABITAT, WHO, UNICEF, FAO, UNESCO and other agencies—have been supportive, sharing information and findings with UNEP. The support of the Governments of Finland and Norway has been indispensable to the ongoing assessment work.

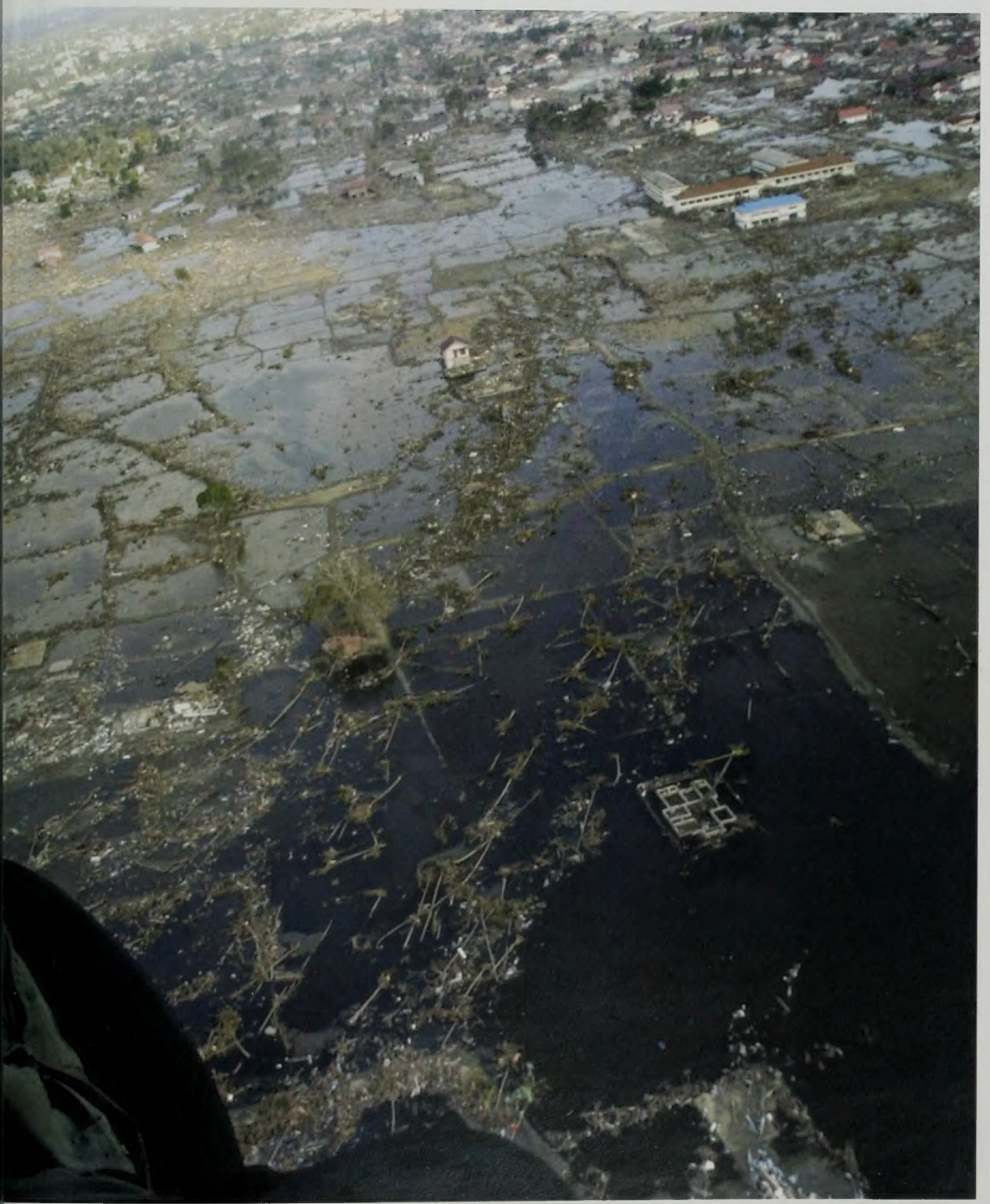
The Task Force's work builds on UNEP's experience in rapid assessments and response. Working closely with UN colleagues, international organizations and counterpart national authorities, UNEP teams have been able to provide policy and technical advice to address pressing environmental needs—such as cleaning up waste to prevent further degradation of groundwater supplies—and have helped to guide the overall environmental recovery process.

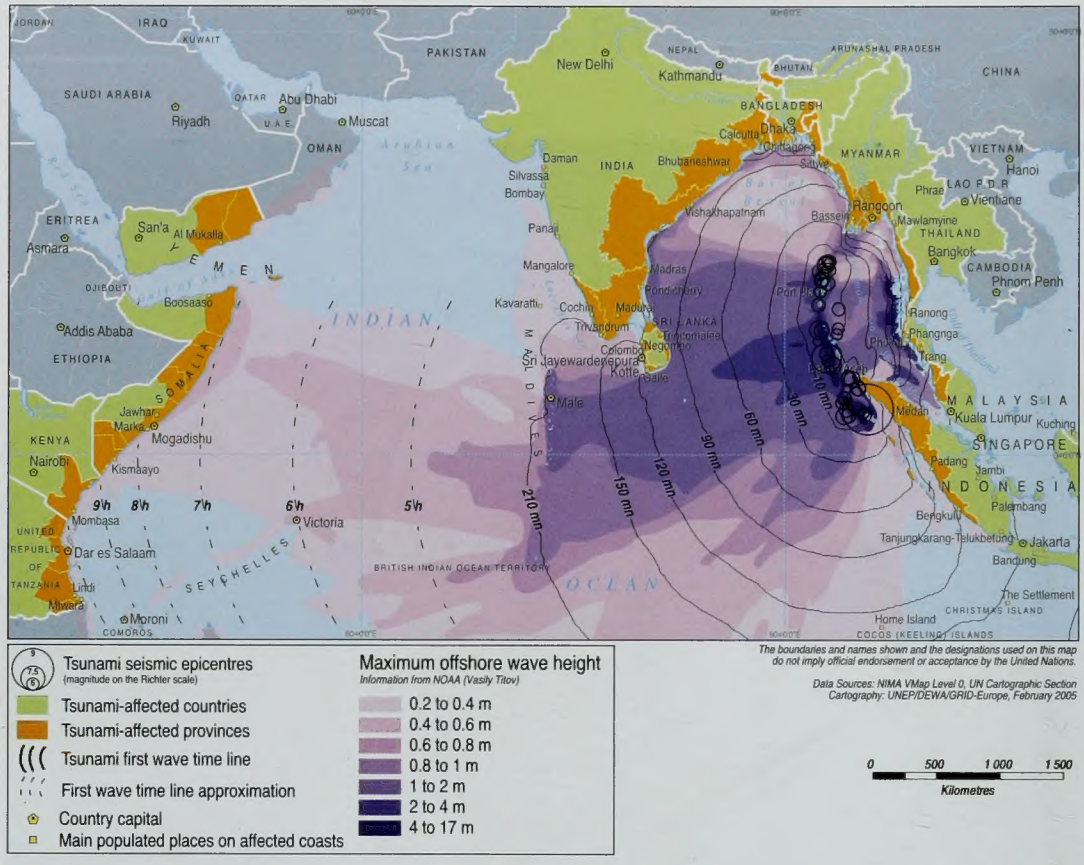
UNEP's experience in the region to date has shown that the tsunami-affected countries are firmly committed to addressing the environmental challenges before them. I strongly believe that this terrible event has provided the countries and communities around the Indian Ocean with an opportunity to focus on the important role the environment plays in their development. I sincerely hope that the extraordinary expressions of support from the global community can be sustained and translated into action that will reduce risks and build a pathway to more a sustainable future for the region's people. For its part, UNEP will continue to respond to any requests from the affected countries for help in the challenging reconstruction process ahead.

EXECUTIVE SUMMARY



Banda Aceh, Sumatra, Indonesia (1 January 2005). A US Navy helicopter flies over Banda Aceh after dropping aid supplies. The 26 December tsunami triggered an unprecedented wave of international support. UN member states and private donors had, by February 10, pledged $4 billion in assistance.
© Patrick Bonafede/US Navy/Reuters





1. EXECUTIVE SUMMARY

1.1 Introduction

The earthquake and tsunami of 26 December 2004, and the events that followed, will be remembered as among the worst human tragedies in history. The loss and devastation caused by this disaster brought incalculable suffering to millions of people around the Indian Ocean. Their grief is shared around the world, and their experience is a humbling reminder that we are all vulnerable to the powerful forces of the natural world that sustains us. From Banda Aceh, to the tourist resorts of south Thailand, to the fishing villages of Sri Lanka, and onward to the coasts of Africa, communities were overwhelmed by the damage and loss.

If counted in sheer numbers, the challenge of recovering from the earthquake and tsunami appears nearly insurmountable. Approximately 250,000 lives have been lost. Millions of people have been displaced and are struggling to restore their homes and regain their livelihoods. The UN Humanitarian Flash appeal estimated immediate needs at $1 billion, but the overall damage is thought to exceed $10 billion.

A snapshot of the region, however, shows a more complex and more hopeful picture. In the weeks since 26 December, the people and the governments of the impacted countries have demonstrated remarkable resilience and determination. Their efforts to alleviate the suffering of affected communities and to put their countries on the road to recovery have been heartening. Even in areas affected by decades-long conflicts, positive signs of cooperation could be observed. At the same time, there has been a remarkable outpouring of concern and assistance from the world community. Together, these efforts have begun to replace despair with a sense of possibility. So far, international public and private pledges of assistance total more than $4 billion.

In response to requests from tsunami-impacted governments, the United Nations system, under the leadership of Secretary-General Kofi Annan and the Under-Secretary-General for Humanitarian Affairs, Jan Egeland, has swiftly mobilized emergency humanitarian assistance. Housing, health care, education, transportation, water and sanitation services have all been rapidly deployed to the region. In all of these efforts, the UN has worked side by side with scores of public and private international relief agencies to address the urgent daily needs of the tsunami victims.

The United Nations Environment Programme (UNEP) has played a vital role in this process. The tsunami was an unprecedented natural disaster with enormous consequences for the region's environment. In the immediate aftermath of the tsunami, on 28 December, UNEP Executive Director Klaus Toepfer created the Asian Tsunami Disaster Task Force, which was charged with responsibility for assisting governments to assess and respond to the environmental impacts of the tsunami.

In response to requests from governments, UNEP immediately deployed experts to Indonesia, Sri Lanka, Thailand and the Maldives, and later to the Seychelles and Yemen. These teams have remained in the region to conduct and facilitate rapid assessments and help coordinate environmental recovery programmes in partnership with national authorities, UN colleagues and the international community.

No government could have been prepared for the events of 26 December 2004. Overburdened environment ministries now have to cope with innumerable urgent tasks. UNEP is supporting government efforts in every way possible: conducting spot assessments of urgent issues; providing specific technical advice; training national counterparts; and identifying priority concerns for international attention.

Working together with governments and other partners, UNEP included a number of priority environmental concerns in the UN Humanitarian Flash Appeal, and has contributed environmental inputs to a number of short-term assessments. At the same time, UNEP has begun preparations for more thorough cross-sectoral assessments of the tsunami's impacts on the environment in the region. UNEP's goal in all of this work is to extract meaningful lessons from the tsunami experience so that governments, donors and international agencies will be able to implement environmentally sound reconstruction programmes in the affected countries.



Banda Aceh, Sumatra, Indonesia (1 January 2005). An Acehnese man walks through rubble left behind by the 26 December 2004 tsunami that devastated coastal communities round the Indian Ocean. Aceh Province, closest to the earthquake's epicentre, was by far the hardest hit. Official figures, as of 9 February 2005, were 242,322 buried or missing, and 412,438 people rendered homeless in Nanggroe Aceh Darussalam Province. The total estimate of damages and losses is $4.45 billion, nearly 97 per cent of Aceh's Gross Domestic Product. © Yusuf Ahmad/Reuters

1.2 Key findings

This report is produced by the UNEP Asian Tsunami Task Force in close partnership with national environmental authorities in the affected countries. It summarizes the interim findings from ongoing environmental assessments in Indonesia, the Maldives, the Seychelles, Somalia, Sri Lanka, Thailand and Yemen, which are the countries that specifically requested cooperation and assistance from UNEP. In Somalia, the report is based on desk study only, as security restrictions did not allow an assessment mission to be fielded. The Government of India did not request assistance, but has shared with UNEP the initial findings of its own environmental assessment.

The assessments give evidence of environmental concerns that require serious attention and immediate action. The short-term clean-up programme must be coupled with policy development and strengthened institutions. The recovery agenda requires an 'environmental reconstruction programme', which will immediately clean up contamination hotspots, start rehabilitation of critical livelihoods and ecosystems and strengthen environmental policies and institutions.

Healthy coastal ecosystems protected people and property. The preliminary environmental assessment has shown extensive, but uneven, damage to the natural resources that acted as the first line of defence from the tsunami, such as coral reefs, mangroves, sand dunes and other coastal ecosystems.

Anecdotal evidence and satellite photography before and after the tsunami event seem to corroborate claims that coral reefs, mangrove forests and other coastal vegetation, as well as peat swamps, provided protection from the impacts of the tsunami. Vegetated sand dunes appear to have provided an excellent first line of defence. The damage to coastal ecosystems is highly variable, and the damage to coral reefs is mostly due to the impact of debris from the land. Coastlines have been eroded, with much of the sediment deposited on healthy reefs, agricultural land, in rivers, or even creating new islands. Shallow soils were stripped from some low-lying atolls.

Sri Lanka offers some of the best evidence that intact coastal ecosystems, such as coral reefs and healthy sand dunes, helped buffer aggressive waves. For example, most of Yala and Bundala National Parks were spared because, vegetated coastal sand dunes completely stopped the tsunami, which was only able to enter where the dune line was broken by river outlets. Some of the severest damage to Sri Lanka's coast was where mining and damage of coral reefs had been heavy in the past. Similar observations were found in the province of Phang Nga in Thailand, where mangrove forests and sea grass beds significantly mitigated the affect of tsunami.

Water and soil have been contaminated. Inland waters, wetlands and agricultural land fundamental to people's livelihoods were salinated. Agriculture yields will be affected in the immediate future. Shallow wells and groundwater supplies, especially in small islands, are now contaminated with saltwater. In some cases, faecal bacteria from damaged or destroyed septic tanks and pit toilets has infiltrated water supply systems.

All 28,000 hectares of coastal irrigation schemes in Aceh were severely impacted. Up to 90 per cent of toilets on some badly affected islands in the Maldives may have been lost. Meanwhile, groundwater in more than 30 islands in the Maldives may have been contaminated by sewage, with tests indicating that many of these supplies now exceed international health limits. In Somalia there is evidence that hazardous waste from coastal dump sites have contaminated groundwater. In the affected areas of Sri Lanka, all of the 62,000 freshwater wells are now believed to be contaminated with salt water and, in some cases, sewage. A survey of wells in the six tsunami-affected provinces of Thailand has found that in Phanga Nga Province nearly 190 out of 530 wells are unsafe due to sewage-related contamination. Villagers on the southeast coast of Yemen report increased salinity of groundwater wells as a problem.

Hazardous debris threatens public health and safety. Much of the debris contains a mix of relatively inert materials plus toxic and hazardous materials. There is an ongoing potential danger to those involved in disposing or recycling such mixed materials. Rapid clean up activities may have resulted in inappropriate disposal methods, including open-air burning and open dumping of asbestos, leading to unnecessary secondary impacts on natural resources.

Somalia's coastline has been used as a dumping ground for other countries' nuclear and hazardous wastes for many years as a result of the long civil war and the consequent inability of the authorities to police shipments or handle the wastes. The impact of the tsunami stirred up hazardous waste deposits on beaches around North Hobyo and Warsheik, south of Benadir. Contamination from these waste deposits has thus caused health and environmental problems to the surrounding local fishing communities. Many people in Somalia's impacted areas are complaining of unusual health problems including acute respiratory infections, mouth bleeds and skin conditions. In the Maldives, solid waste, such as asbestos, fuel drums and large amounts of rubble have been pin pointed as a key issue, along with healthcare, human and animal wastes and oil leaks from damaged generators.

Environmental infrastructure, buildings and industrial sites were damaged. Much of the environmental infrastructure, such as water and sanitation systems, solid waste disposal sites and waste treatment centres, was damaged, particularly in urban areas. There was minimal damage to industrial areas, except in Aceh, Indonesia, but port facilities have been widely damaged. Oil storage facilities, toxic and hazardous materials stored in factories, and oil and bilge water on ships have released dangerous

materials to the environment. Recycling and re-use potential, which would have benefited livelihoods of the affected people, has not been fully exploited during clean-up.

In the affected areas of Indonesia, rural water systems have been badly impacted, with an estimated 60,000 wells and 15,000 hand pumps contaminated, damaged or destroyed. Many people in the Maldives rely on community or individual rain water storage tanks for their drinking water supplies. According to the Maldives Water and Sanitation Authority, more than 90 per cent have been damaged.

Health and environment are intrinsically linked. The potential for high mortality due to water-borne and vector-spread diseases was recognized very early in the disaster. Due to the enormous humanitarian response that was mobilized quickly, appropriate mitigation measures were put in place. As the disaster moves off the front pages of the media, however, there will be a continuing need to protect the survivors from such disease outbreaks.

People's livelihoods were heavily impacted. Disproportionately many of the victims of this disaster were poor people who depended on ecosystem services and natural resources for their livelihoods. Where such sources of income and food were unsustainable prior to the tsunami, it would be regrettable if the opportunity is not taken to find sustainable alternatives. Many victims were involved in fisheries for a living. Particular attention needs to be paid to improved management of coastal fisheries, including control of blast fishing, destructive fishing gear, cyanide fishing, and physical destruction of coral reefs. The sustainable balance between mangrove forests and aquaculture in the coastal areas must be re-established, and small-scale operators mining coral sand or making cement from coral reefs will need to be helped to find alternatives.

Rice crops in the western islands of Indonesia were seen to be yellowing in the fields within three weeks of the disaster. In the Seychelles, soils around Victoria still have a high salt content, which is double the amount most plants in the islands can tolerate. In Sri Lanka, several thousands of fruit and rice farms in areas such as Trincomalee and Batticola Districts have been affected by salt contamination. The agriculture sector in the Maldives was one of the worst hit. Sea water damaged an estimated 1,200 farms and smallholder plots. Over 840,000 timber trees were also damaged on the inhabited islands. More than 20,000 hectares were inundated by sea water in Thailand, with an estimated 1,500 hectares of agricultural land severely impacted.

About two-thirds of Sri Lanka's 29,700 fishing boats were damaged, along with gear and nets. In the Maldives, 120 fishing vessels were destroyed and 50 partially damaged. In addition, 374 fish processors lost equipment and 2 fisheries institutes were damaged. In Yemen, nearly 150 boats were damaged or destroyed. Over 10,000 nets and traps were lost to the sea.

In the Maldives, the tsunami had severe effects on the tourism sector. Eighty-seven resorts sustained damage totalling more than $100 million. In Thailand 315 hotels and 234 restaurants were totally or partially destroyed.

Wildlife avoided harm. Wildlife was rarely directly adversely affected by the tsunami. There is some evidence that birds and larger mammals sensed or perceived the incoming tsunami in time to escape to higher ground. Nevertheless, damage to endangered turtle nesting beaches and breeding projects on the coasts of India, Sri Lanka, Thailand, and Tanzania has been reported.

Excessive demands have been placed on environmental capacity. The capacity of already burdened environmental agencies has been severely overstretched by the added responsibilities of relief and recovery planning and assessments. Many environmental agencies and environmental NGOs have, in some cases, lost staff, facilities and equipment. Capacity building for all environmental agencies was noted as a requirement in all affected countries, covering, for example, integrated coastal zone management, strategic environmental assessment, and integrated economic and environmental planning.



Phuket, Thailand (5 January 2005). Hundreds of volunteers clean Patong beach in Phuket a week after the tsunami. With continued strong cooperation, the countries of the Indian Ocean can establish a course towards recovery that benefits people and the environment. © Pornchai Kittiwongsakul/AFP/Getty Images

1.3 Recommendations

Reconstruction and restoration begins now. Mainstreaming environmental concerns is a prerequisite for sustainable reconstruction. Environmental management should always take as its point of departure the need to involve and engage the affected population. It is fundamental to listen to and understand the feelings and aspirations of people. The rehabilitation and reconstruction of the environment should be people-centred, gender-sensitive and participatory in nature. It is particularly important to focus this effort on the poorest segments of the society, which are at the greatest disadvantage when it comes to adapting to the changes in physical environment and habitat.

The job and income creation potential of the rehabilitation and reconstruction of the damaged environment must be fully exploited. Priority should be given to near-shore forest development, as trees will help absorb the energy of future tsunamis, prevent coastal erosion due to rising sea levels, and meet national objectives for reforestation and job creation. A key feature of the rehabilitation and reconstruction must be to ensure the sustained livelihoods of the people in the areas affected by the disaster and to empower civil society to engage in and respond to the rehabilitation and reconstruction.

Major projects are needed in all affected countries to restore ecosystem goods and services, for example by planting coastal greenbelt forests, reconstructing sand dunes or installing other "soft" defences. International support will likely be needed. Capacity building in techniques for rapid rehabilitation of natural areas is urgently needed. Rehabilitation should use indigenous species rather than risk the negative impacts that could result from the use of alien species. The need for increased attention to "hard" structures, such as emergency centres or seawalls, also requires further study.

Detailed environmental assessments, including vulnerability mapping, will provide critical input into planning for reconstruction and rehabilitation. Further detailed assessment of the role of intact ecosystems is warranted as a fundamental input for reconstruction and rehabilitation efforts. Natural areas that urgently need to be rehabilitated to provide the environmental services needed by the local communities should be highlighted in forthcoming assessments.

UNEP's rapid assessments have identified gaps including:

(i) the lack of vulnerability mapping and comprehensive risk assessment;
(ii) minimal field assessments to date, mainly restricted to areas of high population density;
(iii) the historic lack of environmental baseline data;
(iv) the lack of environmental quality assessments and data on toxic and hazardous wastes that may be mixed with other debris;
(v) the lack of environmental guidelines in national disaster plans, where they exist at all.

Urgent Measures:

Rehabilitate ecosystems. Lost and degraded protective ecosystems must be rehabilitated as soon as possible with adequate coastal zone management processes. Many reefs are now covered with sediment and debris and may suffer more damage unless cleaned.

Repair the infrastructure. The highest priority is to clean, repair and replace damaged environmental infrastructure, such as water wells, sewage lines or water distribution systems.

Clean up solid wastes. The huge volume of debris piled up in the coastal zone by the backwash of the tsunami is a major cause for concern, as some of the material is hazardous (e.g. asbestos). Environmentally sound management of landfills, responsible recycling of materials and treatment of hazardous materials are all urgent needs.

All these efforts should utilize labour-intensive work programmes to provide maximum benefit to re-establishing people's livelihoods and be gender, sensitive and focused on the special needs of the poorest.

Measures to ensure long-term sustainability:

Carry out detailed environmental assessments. Implementation of clean-up and rehabilitation projects, as well as early warning systems, requires a solid body of knowledge on the environmental situation. The assessments should also include vulnerability mapping, which would provide critical input into planning for reconstruction and rehabilitation.

Better coastal zone management land-use planning will reduce vulnerability and environmental stress. The coastal zone will remain a vulnerable area. Community-based Integrated Coastal Zone Management and Planning must be fundamental principles in the reconstruction and rehabilitation.

The rehabilitation and reconstruction effort may cost more than $10 billion, and take possibly a decade to implement. The time and effort required also offers an opportunity to apply concepts of integrated coastal management, including public engagement in local decision making, employ rapid assessment and zoning and planning processes that will promote (i) safe housing, (ii) enhanced ability of natural systems to act as bioshield to protect people and livelihoods, (iii) cost-effective and innovative engineering solutions to control coastal erosion and (iv) the use of best practices in placement of critical public and private infrastructure.

Laws and regulations specifying minimum distances from the shoreline for housing development are important means of protecting against tsunamis, storm surges and sea level rise. Governments, donors

and other concerned stakeholders should be encouraged to implement community-based integrated coastal zone planning and management, enact tougher setback provisions in domestic legislation and enforce the law. Those who lose the rights to use their land as a result of changes in the law may need to be compensated, and donor assistance may be essential for this purpose. Strategic environmental assessment for resettlement projects, as proposed in Sri Lanka, may be worthwhile in other countries also considering relocating people.

Environmental impact assessments are critical. Rehabilitation and reconstruction must be done with due recognition of environmental impact assessments (EIA) of projects and strategic environmental assessments (SEA) of overall plans and programmes. For example, there is a potential threat to natural forest ecosystems from the increased demand for timber products for reconstruction. The capacity of relevant authorities to undertake their role in EIA and SEA processes must be enhanced.

Early warning systems must be put in place. There has been considerable concern that much loss of life and portable property could have been avoided if there had been an adequate early warning system in place. All the affected countries have identified an improved early warning system as a priority. As such systems are expensive to install and maintain for a relatively rare event such as a tsunami, it makes better sense to consider a multi-hazard warning system, as well as a network of national and regional early warning systems as proposed under the Global Earth Observation System of Systems. Development of the early warning systems must be well rooted in national and regional capacity, and it is essential that environmental aspects must be taken into account in the Early Warning System developed by the UN for the region.

Environmental disaster management and emergency plans will improve preparedness. Environmental standards and monitoring, sound management of natural resources together with strong environmental institutions will help to recognize and address environmental vulnerability and lead to stronger disaster preparedness. Environmental disaster management strategies should be coupled with platforms to assess environmental needs and coordinate environmental relief in case of emergencies.

Basic education and environmental awareness could make a huge difference in preparedness. Ordinary people need to know that when the sea retreats more than normal, they need to run for the hills. Indigenous people, who are closer to their natural environment, had this knowledge in their folklore. The same awareness needs to be built into the school curriculum, on beaches (through posted signs), and in tourist literature. The apparent sensitivity of certain animals to the approaching tsunami suggests that observations of animal behaviour may also need to be documented.

Communities need to have agreed emergency and evacuation plans, documented and widely distributed, which are frequently reviewed and updated, based on science-based comprehensive vulnerability and hazard assessment. Each household needs to know what to do in the case of an earthquake, fire or tsunami, or other environmental disasters. They need to have a mental map of their evacuation route as well as a deeply ingrained willingness to leave their property behind and protect their lives. Tourist operators need to have similar emergency plans, and in all vulnerable areas make sure that their guests have standard information available in a range of different languages.

Strengthen environmental institutions. The ongoing efforts of authorities and organizations in affected countries to address the urgent environmental challenges posed by the tsunami demonstrate their strong commitment to environmentally sound reconstruction. This spirit should be joined and fully supported by the international community. With continued strong cooperation between national and international actors, the region can establish a course toward recovery and protection of its extraordinary natural heritage and the restoration of livelihoods. Institutions often need direct technical assistance. However, assistance should be combined with capacity building activities in the priority areas of integrated waste management, environmental impact assessment, coastal zone management and environmental disaster management and early warning.

INDONESIA



Banda Aceh, Indonesia (27 January 2005). Ida, a female elephant and her mahout take a break as a body removal team works in the background. Eight elephants from the Indonesian Forestry Commission were working in and around Banda Aceh to help clear the debris from the tsunami.
© Charles Pertwee/Getty Images



2. NATIONAL RAPID ENVIRONMENTAL ASSESSMENT - INDONESIA

2.1 Introduction

Within minutes of the earthquake, the first tsunami waves struck the Indonesian Island of Simeule, located approximately 40 kilometres from the epicentre. Waves between 15 and 30 metres high then proceeded to the western and northern coasts of Sumatra, causing massive damage to thousands of kilometres of coastline in Aceh and North Sumatra Provinces and the western islands. A rebound effect then occurred, with waves pounding parts of the east coast of Sumatra. Based on this sequence, the extent of flooding varied from an average of 500 metres on parts of the east coast, to two kilometres on the west coast. Seawater surging up rivers and estuaries went as far as six kilometres upstream.

The combined destructive impact of the earthquake and the tsunami was enormous. The human cost is still being counted, and will probably never be fully known. Official figures as of 10 February 2005 are 164,891 people buried, 114,897 people missing and 412,438 people displaced. The total estimate of damages and losses is $4.45 billion, nearly 97 per cent of Aceh's Gross Domestic Product (GDP). The impact on lives, families and communities cannot be counted in dollar terms.

The sheer magnitude of the impact initially destroyed much of the communication and transport infrastructure in the worst affected region. The Indonesian Government (GOI) was quick to declare a national disaster. It took some days before the full impact of the event was realized. Due to the destruction of road transportation infrastructure along the north and west coasts, many communities could only be reached by foot, boat or air transport. The Indonesian military provided initial logistical support, quickly reinforced by other nations. Local efforts mobilized numerous volunteers providing general assistance and immediate burial of bodies, work which continues today.

Under the direction of the UN Resident Representative in Indonesia, specialized UN agencies were mobilized to provide immediate humanitarian relief. The UN estimated that 550,000 people needed humanitarian support on the east coast and in Banda Aceh. A multi-agency assessment also found some 125,000 internally displaced people (IDP) along the west coast. These figures, combined with those who died, indicate that at least 1 million people were either killed or displaced, with those indirectly affected being much higher. The UN flash appeal identified $977 million worth of immediate disaster relief needs, with $474 million directed to Indonesia.

2.2 Overview of the Environmental Response

Ministry of Environment (MOE) staff arrived in the region within three days of the event and were able to gain a broad understanding of the situation and needs on the ground. They immediately established an emergency group of staff and volunteers working from an emergency operations centre. Through this structure, the MOE was able to carry out preliminary site assessments, data collection, sampling and analysis to feed into the initial phase of the emergency planning and coordination process, as well as subsequent recovery and rehabilitation planning. It is expected that the MOE will have a major advisory role in the rehabilitation process to ensure that reconstruction and rehabilitation are undertaken in an environmentally sustainable way.

In the days following the disaster, UNEP was requested by the MOE to provide technical assistance in identifying the environmental impacts and risks of the disaster, as well as the recovery needs. In response, a team of environmental experts were mobilised on 1 January 2005. An expert from the Joint UNEP-OCHA Environment Unit was also mobilized to join the UNDAC team to conduct a rapid environmental assessment (REA). At the same time, UNEP, through the UN Country Team for Indonesia, requested $1 million in the UN Flash Appeal for environmental assessment and for emergency risk reduction activities in Sumatra.

Working in partnership with national experts from the MOE, the UNEP team analyzed environmental impacts and participated in the damage assessment, which was conducted by the National Development Planning Agency (BAPPENAS) and coordinated by the World Bank. The initial BAPPENAS damage and loss assessment included an economic valuation using internationally accepted methodology for replacement, rather than reconstruction costs. Figures on damage and loss estimates within this report, unless otherwise indicated, are drawn from the BAPPENAS document. UNEP acted as the lead in the environmental sector, and calculated total damage to environmental assets as $155 million, with total losses of environmental services equalling $515 million. UNEP also worked to develop a joint proposal for strengthening environmental disaster assessment and response capacity within the MoE.



Banda Aceh, Indonesia (15 January 2005). An employee of the Indonesian Environment Ministry collects a water sample for analysis. Standing water left by the tsunami in Banda Aceh tested by the Indonesian Environment Ministry shows high levels of faecal coliforms, consistent with sewage contamination.
© Jewel Samad/AFP/Getty Images

Other assessments and activities in the environmental sector were divided between a number of national and international actors. The most important was taken by the MOE and GTZ in conducting a series of REAs. The MOE's REA process in the affected region uses the following three steps:

- Stage 1—Organizational-level assessment to identify critical environmental issues related to the disaster from the perspective of organizations who provide relief and recovery assistance.
- Stage 2—Community-level assessment to identify issues from the affected community's perspective.
- Stage 3—Consolidation and analysis to identify and prioritize environment-related issues, especially those that may threaten lives, well-being and the environment.

The first REA was completed for Banda Aceh in mid-February, and others are planned for Meulaboh, Calang, Pulau Nias, as well as one on rural needs. The findings and identified priorities from the initial REA for Banda Aceh have been included, particularly in the recommendations section of this report.

Other international actors also conducted key assessments with linkages to the environmental sector. FAO conducted initial aerial surveys of impacts to agriculture and fisheries, and are now in the process of conducting ground sampling. Early reports indicate that on-site conditions are highly variable, but that significant salinization of soil and groundwater has occured. Information obtained on soils and water contamination will be critical in understanding cross-sectoral rehabilitation challenges.

UNESCO has initiated a voluntary Environmental Assessment Coordination Network in support of local and international NGOs and academic institutions to make first assessments of coral reefs, mangroves and sea grass. Common methodologies will be based on IUCN guidelines developed for these resources.

UNDP is planning a broad-based livelihoods survey of the affected area. It will include local environment and human health considerations, and UNEP will provide relevant technical inputs where possible. UNDP, together with OCHA, have developed a Tsunami Recovery Waste Management Programme, with an initial pilot project in Banda Aceh. The programme is being coordinated with relevant local and

national authorities, seeking to combine the principles of waste volume reduction through reuse, recycling and composting, along with appropriate safety handling procedures for staff, and the maximization of labour use for livelihood support among the affected population. It is intended that the programme become a model for other affected centres in need of waste management programmes. It will be replicated by UNDP/OCHA as part of their programme as quickly as possible in other parts of the affected region.

UNICEF is taking the lead on water and sanitation coordination and funding emergency water and sanitation projects through the Ministry of Public Works. Specific projects include pumping and chlorinating 1,500 wells in Banda Aceh and Aceh Besar districts to benefit 15,000 people; installation and operation of UNICEF-supplied mobile water treatment units at six locations along both east and west coasts to benefit 25,000 people; and construction of emergency latrines and bathing and washing facilities in IDP settlements for 43,000 people.

UN-HABITAT is a partner in two UNDP-led projects on housing rehabilitation for 175,000 families (including water and sanitation) and restoration of minor infrastructure for 8,300 families, including rubble clearance.

Within the international NGO community, WWF is working to strengthen representation from Aceh in the current planning process through engagement of civil society representatives from the region. They are also highlighting environmental issues that may be associated with the recovery and rehabilitation process, in particular potential deforestation caused by high demands for reconstruction timber (see case study on timber).

IUCN has released rapid assessment guidelines for tsunami-damaged coral reefs and a decision-makers guide on the rehabilitation of natural environments and livelihoods following the tsunami. Two further practical restoration guides are being developed on sustainable tourism and sustainable fisheries.

Wetlands International is working to collate latest information from sectoral departments in order to complete a prioritized listing of coastal wetland restoration needs by district. A preliminary listing is being updated as new information becomes available.

Finally, Flora and Fauna International (FFI), with its long history of working in the region, is working closely with other conservation, development and humanitarian organizations, using its knowledge of local issues to underpin long-term environmental planning.

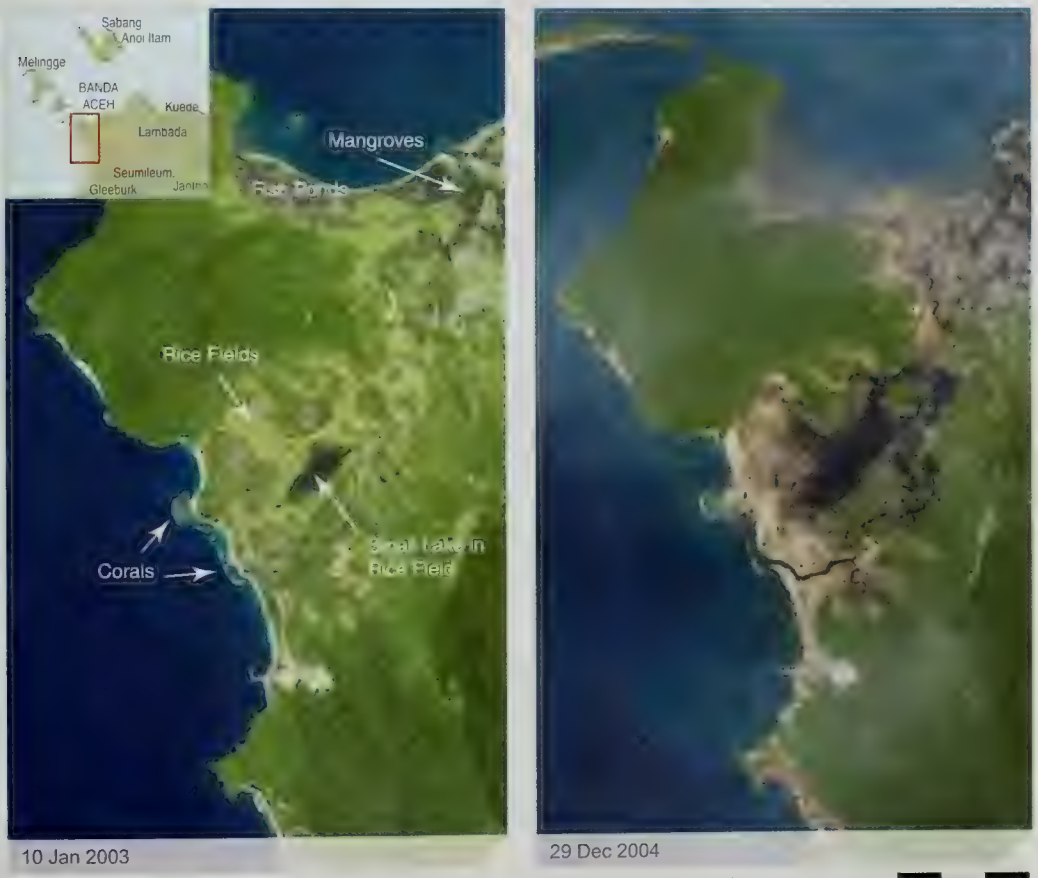
Many of the figures regarding environmental impacts contained in the following summary were necessarily based on incomplete and dated data sets. Much of the affected region was not easily accessible during the past 20 years due to the ongoing Aceh conflict between separatist groups and GOI. The current early stage of the post-emergency assessment process precludes much ground-truthing or quantitative data analysis. This more detailed process of assessment is beginning, but will take some time and still faces considerable logistical challenges. Access to Aceh region remains restricted to Banda Aceh and the town of Meulaboh except with special permission and an Indonesian military escort.

2.3 Preliminary Findings: Impacts on the Natural Environment

It is almost impossible to convey the enormity of this event. Satellite imagery begins to convey the scale of the impact (see text box case study). Before-and-after images show the significant changes to base physical landscape characteristics (see case study). Site photos only begin to convey the immediate effects on the ground. The scale of the phenomenon is a challenge both in terms of making general comments equally applicable across the affected region and in extrapolating the results from the limited environmentally focused assessments initiated so far. Nevertheless, the main preliminary findings from the early work are summarized in the following sections.

Case study: Overall damage to ecosystems in Sumatra

These images show a combination of a rocky, hilly headland along with a small river delta and swampy coastal strip. A low-lying wetland area connects the northern and western ocean fronts. An integration of natural and agricultural ecosystems operating prior to the tsunami combined rice cultivation, and fish/shrimp ponds (tambak), alongside natural delta mangrove forests and wetlands. Coastal forests and onshore reefs are also present. The effect of the tsunami is clearly evident. It scoured out the low lying delta land, destroyed fish ponds and removed mangrove cover. Volumes of soil and silt have evidently been carried out to sea expanding the area of the small lake by a factor of approximately 10. There has been removal of the sandy beaches (important in some locations for turtle nesting) and deposition of silt or mud on the reef. Apparently minor effects on the integrity of the rocky vegetated shoreline surrounding the headland are likely due to the resilient nature of the substrata, as well as dense natural vegetation cover and the sloping nature of the shore.



Sources: Images acquired and processed by CRISP, National University of Singapore, IKONOS image © CRISP 2004, http://www.crisp.nus.edu.sg/tsunami/tsunami.html
Ibu Lana & Fauzal Parish, 2005, Preliminary Assessment of Tsunami Impact on Ecosystem in Aceh, Min. of Environment & Global Environment Centre
Created by UNEP/DEWA/GRID-Europe, February 2005

Coral Reefs, Sea Grass Beds and Sandbars

There were an estimated 100,000 hectares of coral reefs in the affected area providing critical ecosystem functions. According to Wetlands International, coral reef ecosystems are found mainly in the waters of northern Aceh, including Weh Island, Pulo Aceh Islands and the western waters of the Simeulue and Banyak Islands. A scientific inventory of the distribution and status of coral reefs has never been carried out in Aceh, largely due to limitations on secure access. The marine ecosystem in this area supports critically endangered Leatherback and Hawksbill sea turtles, as well as endangered Green Sea Turtles. Functionally, they also serve to trap coastal sediments, and provide coastal protection from high waters. Highly productive sea grass beds, totalling approximately 600 ha, are found off the coast of Nias and off Pulau Weh and Banyak Islands. The sea grasses of the Pulo Aceh islands are inhabited by dugongs, a species specific to the sea grass ecosystem.

Priority Ecosystems and Protected Areas in Sumatra



website: www.unep-wcmc.org

please contact Kaveh Zahedi or Phillip Fox for further details

All data on Protected Areas, Coral Reefs, Seagrasses and Mangroves are available from UNEP WCMC databases.
Data on population density kindly provided by CIESIN.

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The BAPPENAS initial damage assessment estimated 20 per cent loss of sea grass beds, approximately 600 hectares, for a net loss of $2.3 million ($2,684/ha estimated value). For coral reefs the estimated valuation of 30 per cent damage to 97,250 hectares is a net loss of $332.4 million ($1,599/ha). Wetlands International has also conducted preliminary assessments of the impact on sea grass in a number of Islands. Early results suggest extensive damage to sea grass beds in Pulo Aceh, with less severe but significant impact in the Simeulue and Weh Islands. Wetlands International has also identifed that the most serious damage to coral reefs is likely to be around the Pulo Aceh Islands. Reports from initial dives off Pulau Weh (Weh Island) indicate that there is some reef damage between one and three metres below the surface, but coral appears to have suffered minimal damage (less than 10 per cent) beyond three metres. Damage to Simuelue Island is believed to be moderate, with the coral around the Banyak Islands still in good condition.

The most serious threat to the coastal environment from the tsunami currently stems from the massive amounts of natural and man-made materials that were dragged into the ocean by the receding waters. This waste ranges from vehicles and fuel tankers to silt and debris, including whole trees. In the case of Calang and Teunom on the West coast of Sumatra, almost all above-ground infrastructure was sucked into the ocean by the tsunami. Aerial photos of the zone show surprisingly little remaining debris. The main risk is that this debris is causing secondary damage to the coastal environment by being continually pounded into delicate ecosystems by normal wave action. The extent of the problem is currently unknown.

An additional concern of note relates to the impact on sandy beaches. Wetlands International estimates a loss of 50% of sandy beaches on the west coast. This loss may have impacted turtle nesting sites, with possible negative effects on Hawksbill, Leatherback and Green turtles. Further information on the impact on known nesting sites will form a necessary part of a detailed environmental assessment.

Mangroves and Coastal Forests

The coastal zone of the northern and western portions of Aceh include five of the 10 main vegetation types found in the island of Sumatra: mangrove, peat swamp, lowland evergreen and lowland semi-evergreen forest types, and forest restricted to limestone. Mangrove forests around Banda Aceh had predominantly been replaced by tambak (shrimp farms). The total tambak area, estimated to be 36,000 hectares, is likely to have been largely comprised of former mangrove sites. On the west coast, sandy shores predominate, and only patchy mangroves were found. In 2000, Wetlands International estimated there were 30,000 hectares of mangroves in good condition around Simeuleu Island. A further 286,000 hectares remained in fair condition and 25,000 hectares in poor condition. Critical mangrove functions include nursery and feeding grounds for coastal and riverine fish and prawns. They also provide concurrent coastal/delta protection from surges and floods, as well as filtering water before it reaches coral reef and other offshore systems. The region of northern Sumatra provided an important collection point for young prawns for sale to the aquaculture industry in other parts of the country.

Initial estimates indicate that approximately 48,925 hectares of coastal forests (other than mangroves) were impacted by the tsunami. The economic value of this loss is calculated at a net present value of $21.9 million. The BAPPENAS assessment estimates approximately 90 per cent damage to between 300 and 750 hectares of mangrove forests, yielding a net loss of $2.5 million.

Estuaries and Wetlands

The northern provinces of Sumatra are rich in water resources. A total of 73 streams and rivers feed the estuaries and wetlands. Rivers tend to be short and fast flowing. The difference in contours, height of waves and type of substrate between the east and west coasts has created different dominant wetland types. On the east coast of Aceh there are many mangrove ecosystems comprised of *Rhizophora*. Coastal trees such as ketapang, coconuts, and pandan dominate the west coast, with few mangroves.

Case study: Impact on aquaculture

These images show a close-up view of the northern coastal area of case study 1. Features include a swampy coastal strip of land which has largely been converted to tambak. Part of the inland estuary is covered in *Rhizophora* mangroves, which are important spawning and nursery grounds for the milkfish and prawns traditionally raised in the tambak ponds. Further tambak ponds are located inland on the estuarine system. The post-tsunami image shows the devastating effect of the tsunami on the low-lying lands. The force of the water is able to travel up estuarine systems, often up to 6 kilometres inland. The western strip of coastal sandbar has been completely removed and tambak ponds destroyed, along with the majority of the mangroves. Clearly, a vast volume of material was carried out into the ocean. Devastating effects on housing infrastructure are also evident.



Sources: Images acquired and processed by CRISP,National University of Singapore. IKONOS image © CRISP 2004, http://www.crisp.nus.edu.sg/tsunami/tsunami.html
Ibu Lena & Fazal Parish, 2005, Preliminary Assessment of Tsunami Impact on Ecosystem in Aceh, Min. of Environment & Global Environment Centre
Created by UNEP DEWA/GRID-Europe February 2005

Tsunami impacts varied according to the shape and slope of the of the ocean floor, the presence or absence of reefs, mangroves and onshore forests, the orientation of the coast and the slope of the coastline, and underlying rock and soil types. Image analysis shows that some areas have been highly modified by the tsunami. Estuary and wetland areas have apparently been scoured out and drainage patterns changed. Other areas appear to show evidence of subsidence or drainage changes leading to potential new wetland areas. For example, the west coast of Nias Island is estimated to have risen by 5 metres, due to earthquake effects, yet suffered no direct tsunami damage, with associated impacts to be expected on coastal drainage patterns.

It remains to be seen whether river systems affected by the tsunami will require dredging. Riverbank stabilization using vegetative strategies may be necessary or useful in some cases. The damage and loss assessment estimated that some $2.3 million might be needed for river rehabilitation.

Surface and Groundwater

Water resources in the provinces are locally abundant due to high rainfall levels (1,000–3,000 mm/yr). The tsunami contaminated surface waters in many areas near human settlements as the contents of septic tanks were mixed with seawater and other surface materials. Streams and rivers are generally anticipated to have flushed clean, but the effect of saltwater and other materials intrusion into groundwater systems is of concern. The cost of rehabilitating shallow wells is projected at $1 million.

Soils

Heavy clay soils predominate in the affected region. In many areas soils were inundated with salt water. There is concern that the fertility of salinized soils will be affected in the short to medium term as a result. Rice crops in the western islands were seen to be yellowing in the fields within three weeks of being inundated. FAO has indicated a zoning system for soil recovery based on three zones:

- Class A: rapid reclamation and salt leaching is possible either through normal rainfall or irrigation and where land could be productive for the April/May cropping season without major intervention.
- Class B: special works are needed to reclaim the soil and restore the land surface. Farmers may need to grow salt-tolerant crops during the next season and partly divßersify production.
- Class C: reclamation in time for the next cropping season is unlikely. Farmers could be compensated for abandoning their land or assisted in diversifying into other economic activities.

According to initial asessment figures from FAO, approximately 30 per cent of farmland is affected on the north east coast, and 70 per cent is affected on the west coast – with a general estimate of 20 per cent of affected land overall as permanently damaged.

Rough initial estimates of damage to farmland are some 9,000 hectares on the east coast and 27,000 hectares on the west coast. An additional 50,000 hectares of wetland and dryland were affected.

In population centres, such as Banda Aceh, Meulaboh and Calang, soils were mixed with rubble, sewage, municipal solid waste, and household and small business items, such as fuels, oils, cleaning chemicals, solvents etc. The full impacts are still to be fully analysed. Soil tests from Banda Aceh confirmed the presence of high ammonia levels.

Marine and Terrestrial Protected Areas

Two marine protected areas are located within the disaster zone: Pulau Weh Marine Reserve (3,900 ha) and Kapulauan Banyak Marine Recreation area (227,500 ha). Based on Ramsar criteria and the Wetlands International database, there are seven additional areas of international importance in Aceh. These include:

- Kuala Jambu Air (10,000 ha). Estuary with mixed mangroves.
- Blok Kluet, Gunung Leuser National Park (200 ha). Freshwater swamp and peat swamp forest. Includes endangered species such as Leatherback turtles, Sumatran tiger, and orangutan.
- West Singkil (5,500 ha). Relatively undisturbed beach forest series and freshwater swamp forests in excellent condition. The best surviving examples of these habitat types in the province, with all their characteristic flora and fauna. Includes rare and vulnerable species.
- Simeulue Island. Coastal wetlands in the area include approximately 1,000 hectares of mangrove forest, coral reefs and sea grass. Includes endemic fauna and endangered species, such as Leatherback, Hawksbill and Green Sea turtles.
- Bangkaru Island, some surviving beach vegetation, lowland forest. Probably the most important nesting site for Green turtles in western Indonesia.
- Pulo Aceh Island Group. Located on the west side of the Banda Aceh Sea, consisting of Breueh Island, Nasi Island, Teunom Island, Batee Island and several other small islands. The 1998 spatial plan for the district of Aceh Besar included plans to designate a protected marine area for Pulo Aceh. Some prior damage from dynamite fishing has affected *Arciporra sp* coral reefs in the waters of the district of Aceh Besar.

Detailed assessments have not yet been conducted on impacts to terrestrial and marine protected areas from the tsunami. However, WWF has noted that the proximity of the Gunung Leuser ecosystem and National Park to the impacted areas is of concern. Timber demands for tsunami reconstruction, together with the proposed Ladia Galaska road through the Leuser ecosystem, would open up currently inaccessible areas to potential illegal logging and other detrimental effects on the ecology and biodiversity of the ecosystem.



Lhok Nga, Indonesia (5 January 2005). Aerial view of a cement factory at Lhok Nga, south of Banda Aceh, Indonesia. The plant employed more than 600 people before the earthquake. The tsunami damaged an estimated 80 per cent of the facility and killed one-third of the workers. © Reuters/Choo Youn-Kong

Case Study: Sustainable wood supplies for reconstruction in Aceh



Source: H-J.Stibig, R.Upik, R.Beuchle, Hildanus, S.Mubareka, 2003, The Land Cover Map for South East Asia in the Year 2000, GLC2000 database, European Commision Joint Research Centre
NIMA VMap Level 0, UN Cartographic Section, ESRI Arcworld, IUCN

Cartography: UNEP/DEWA/GRID-Europe, February 2005
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Pristine forests in Sumatra



Source: Collins, M., Sayer, J. et Whitmore, T., 1991, The conservation atlas of tropical forests: Asia and the Pacific, Toronto (Ont., Canada), Simon and Schuster
UN Cartographic Section, ESRI Arcworld
Logged forests are excluded from this overview.

Reconstruction and the rebuilding of communities will create considerable demand for timber. The projected demand is estimated at between 4 and 8 million cubic metres of logs. If this was to be supplied from local sources it would mean logging between 125,000 and 250,000 hectares of forest. WWF-Indonesia and Greenomics have concluded that legal and sustainably harvested logs from within Indonesia are insufficient to meet this timber demand. They have proposed that donor governments provide sustainably sourced timber 'in kind' as part of their aid programme. The programme would operate through a Presidential Decreed Special Task Force that would generate, process and track the donations. Illegal logging and consistent shortfalls of domestic production compared with demand could mean that natural areas close to the tsunami impacted zone would be vulnerable to exploitation if timber imports are not increased or innovative solutions, such as the one proposed, are not implemented. The Gunug Leuser Ecosystem—a major critical habitat for Sumatran orangutans, tigers, elephants and rhinoceros—is already under pressure from illegal logging, and could be a target for accelerated logging processes under a worst case scenario. More information is available from the WWF/Greenomics 2005 publication A Preliminary Assessment of Timber Requirements for Aceh's Reconstruction, and Its Implications.

2.4 Preliminary Findings: Impacts on the Human Environment

Industrial Sites and Ports

The region was not heavily industrialized, although heavy damage affected 14 public port facilities in Aceh and North Sumatra, with light damage to another five ports. Three key industrial sites were confirmed as damaged by the UNDAC assessment: the Pertamina oil depot in Kreung Raya Bay/Banda Aceh; the Pertamina oil depot in Meulaboh; and the Semen Andalas Indonesia cement factory in Banda Aceh. Oil storage prior to the disaster was confirmed at 40,000 kilolitres of oil in eight tanks in Banda Aceh, and 5,000 kilolitres of oil in one tank in Meulaboh. About 8,000 kilolitres of oil reportedly leaked from the Banda Aceh facility.



Meulaboh, Sumatra, Indonesia (6 January 2005). Damage from the tsunami seen from a United States Navy helicopter.
© Jordan R Beesley/US Navy/Getty Images

An environmental assessment by UNDAC and the Joint UNEP/OCHA Environment Unit regarding potential toxic exposure from sites in and around Banda Aceh concluded that due to the enormous quantities of water washing materials away from chemical depots and other potential 'hotspots', there was little potential acute impact on public health or the environment from exposure to hazardous chemicals or radioactive materials, as compared to the overall disaster situation.

Further detailed soil and groundwater assessments will help to establish the degree to which any localized contamination may have occurred, but it appears that specific investigations in relation to industrial 'hot spots' of contamination is not urgently required.

Waste

A rough order calculation for the city of Banda Aceh alone estimates the volume of waste at between 7 and10 million cubic metres. The effect of the tsunami was variable. In some parts of the west coast, most debris was swept out to sea. The composition of the waste material in former population centres is also varied. There are high volumes of mud and sand in Banda Aceh (less so in Meulaboh) and nothing visible is left in Calang. The other main constituents are, in rough order of volume: bricks and concrete; wood (planks and trees and other organic matter); some plastics and metals (iron, aluminium and copper). Overall, an estimated 80 per cent of the waste being collected consists of soil, building materials or vegetative matter.

An unknown quantity of potentially hazardous waste was created from household and small-scale industrial chemicals, fertilizers, and fuel, with greater potential for such materials in Banda Aceh than in other centers. Disposal risks include contamination to soil and groundwater.

The tsunami backwash dragged large amounts of material out to sea that was deposited inshore and further offshore. Future assessments will need to account for potentially damaging solid waste lodged in reefs and other marine ecosystems that may require removal.

In towns, the waste facilities that existed before the tsunami were located on the coastal strip. When the tsunami hit, the waste was first carried inland, some was then washed back, while some was mixed with other debris. Consequently, routine collection of urban municipal solid waste post-tsunami has been hampered by the loss of landfill sites, equipment and staff. The landfill sites were not run according to internationally accepted standards before the disaster. As of 4 February 2005, the only municipal solid waste collection in Banda Aceh is focused on IDPs and the hospital. As noted previously, UNDP/OCHA have proposed a Tsunami Recovery Waste Management Programme, with an initial pilot project in Banda Aceh.

Water Distribution and Irrigation

Before the disaster, only about 9 per cent of the total population in Aceh Province and 24 per cent in North Sumatra Province had access to piped water supply. Self-provided and community based systems served the bulk of the population, mainly based on wells and springs. Sanitation across rural and urban areas was provided mainly by septic tanks and pit latrines. It is assumed that septic tank management was marginal, and sewage treatment plants partly operational before the disaster.

Rural water systems have been badly affected by the disaster, with many thousands of wells and boreholes damaged, destroyed or contaminated an estimated 60,000 wells and 15,000 hand pumps. In these cases, urgent needs are for replacement, cleaning and disinfection. Mobile water supply has been a strong focus of the relief effort, through the action of relief actors (UN, NGOs and the military) in support of local government and GOI efforts. UNICEF reports that no more than 20 per cent of the construction of latrines and water supplies in the spontaneous IDPs settlements meets minimum SPHERE standards, with clear risks to human health and the environment.

Sanitation systems have been flooded and destroyed by the tsunami, with the contents in many cases mixing with the tsunami waters. Risks include the passage of water-borne diseases, gastric complaints, typhoid and cholera. Standing water left by the tsunami in Banda Aceh has been tested by the MoE, and shows high levels of faecal coliforms, consistent with sewage contamination. This can probably be extrapolated to other population centres, where water quality was also problematic prior to the tsunami.

There are some 465 irrigation schemes, covering 335,084 hectares in Aceh. All 28,000 hectares of coastal irrigation schemes were significantly impacted by the tsunami. Additional damage to flood protection dykes and related infrastructure is also apparent.

Energy

Approximately 60 per cent of Aceh's households had access to electricity before the disaster. Installed generation capacity is predominantly based on diesel generation. A 150 KV transmission line running south from Banda Aceh along the northeast coast to Medan forms the main power corridor and remained undamaged. Energy distribution networks for both electricity and petroleum were also damaged to a degree (see findings on industrial sites).

Large natural gas resources being extracted by Exxon Mobil and supplied via pipeline to the Arun LNG plant and also to large industrial fertilizer plants on Aceh's east coast have not been affected. No gas distribution network exists in Banda Aceh or other parts of Aceh.

Temporary Housing

Initially, displaced people gravitated towards ad hoc temporary camps, the number of which has subsequently dropped from 385 to less than 100. These camps faced challenges of water and sanitation, as well as waste disposal. UN OCHA says although relief items continue to reach all populations in Indonesia's Aceh Provonce, the targeted assistance is proving to be challenging due to frequent movements of displaced populations between spontaneous sites, host communities and their places of origin.

The GOI says that by the end of February, 401 barracks to house the homeless would be ready, with enough room for some 50,000 people. The GOI had planned to build some 754 barracks in 39 locations. There are a total of some 425,000 IDPs. A second group of 40,000 will move into prefabricated homes, and 320,000 will be relocated into military platoon tents. Officials began a census on 1 February, and relocations were planned to begin on 15 February. Indonesian officials expect about a third of the IDPs to move into temporary housing, while the rest will likely stay with relatives. An estimated 260,000 IDPs are already staying with extended families.

In relation to the construction of barracks and temporary shelters, the issue of timber supply has been raised by WWF. The current status of timber extraction in Indonesia is that 80 per cent is already extracted illegally, and that current available legal supply would be inadequate for the between four and eight million cubic metres of logs required for the recovery and reconstruction process (See Case study).

2.5 Preliminary Findings: Environmental Management Capacity

Environmental Framework Laws

Following the fall of the Suharto regime in May 1998, widespread demands came from Indonesia's regions for more powers over local natural resources and a greater say in decisions that affected their daily lives. As a result, under the 1999 Regional Autonomy Act, District Level Environmental Agencies took on core jurisdiction from the State Ministry for Environment for environmental management in Indonesia. While local agencies served as close partners with the national government in the pre-decentralization era, the modern environmental governance regime is characterized by fully autonomous local agencies. However, despite being delegated, the vast majority of powers for environmental control, local environment agencies existed in only about 163 of Indonesia's 374 Districts as of 2002.

In provinces with rich natural resources, the demands for local autonomy have been even greater, leading to Special Autonomy regimes for Aceh and Papua. These provide increasing local authority over natural resource use, retention of revenues and establishment of local regulatory frameworks based on local customs and traditions.

Generally, the tsunami has had a major impact on general governance systems in Aceh. Assessments are required to identify the sub-set of these impacts which affect environmental governance specifically. Generally, 14 out of 21 local governments in Aceh, and 3 out of 23 in North Sumatra, have been severely affected and are not yet operational. In addition, more than 10,000 public employees in Aceh province were affected. This amounts to about 21 per cent of the 47,569 civil servants working in Aceh province. About 20 per cent of government buildings in Aceh were damaged or destroyed. It is anticipated that the same level of devastation has been experienced by civil society as a whole, including those groups with specific interests and expertise on environmental issues.

Environmental Impact Assessment

The reconstruction plan of Aceh Province, in particular the reconstruction of Banda Aceh and Meulaboh, may cause important impacts to the environment. Normally the activities would be subjected to an Environment Impact Assessment (EIA) as stipulated under article 3(1) and 3(2) of Government Regulation Number 27/1999. In cases of emergency due to disaster such as the recent tsunami, reconstruction activities are no longer subjected to EIA, as the reconstruction process is so urgent that the standard EIA process is no longer appropriate.

The extent of the destruction of the region is also so large that the conventional project-based EIA is no longer appropriate. It is more important that a spatial plan, based on a carrying capacity approach, be applied to the region. The competitive advantages of Aceh, such as human resources or natural resources, should be identified in such a way that the environment is sustainably managed. In this context, the application of a Strategic Environmental Assessment (SEA) approach may be more appropriate.

To facilitate the incorporation of the environmental aspects in the reconstruction process, the MOE has proposed a checklist for evaluating the environmental conditions as well as a checklist for planning. The checklist, although voluntary, will be important in evaluating the necessary environment impact management relevant to the reconstruction. UNEP is planning to provide technical support in this area in the coming weeks and months.



Port Louis, Mauritius (13 January 2005). Rachmat Witoelar, Indonesian Minister for the Environment, addresses the plenary session of the International Meeting to Review the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States. The Mauritius Declaration highlighted the need to develop and strengthen effective disaster risk reduction, early warning systems, emergency relief, and rehabilitation and reconstruction capacities. © Marco Longari/AFP/Getty Images

Coastal Zone Management

The 'Program Pantai Lestari' (Sustainable Coast Programme) run by the MOE was initiated in 1996. It is a national programme, but not implemented in all provinces. It works through local governments, tasked with the implementation of resource management. The most advanced example of programme implementation is the Bali Demonstration Project for Integrated Coastal Management. This model could serve as a basis for the future coastal zone management of the tsunami-impacted area in Sumatra.

Early Warning System

Indonesia's limited early warning system currently consists of a tide gauge network with 54 permanent stations operated by Bakosurtanal and 10 permanent stations operated by PT Pelindo. It can be expected that the final form of the regionally enhanced early warning system will also serve to strengthen local early warning capability, with the integration of existing capacities leading to the execution of contingency plans and standard operating procedures to be followed in the case of an alert.

Disaster Management

Indonesia is at risk from an array of natural and man-made disaster threats including occasional flooding, severe drought, tsunamis, earthquakes, landslides, volcanoes and forest fires. At the national level, the Indonesian National Coordinating Board for the Management of Disaster and IDPs/Refugees (BAKORNAS) works as the coordination mechanism for major emergencies, with BAPPENAS, the central governmental planning agency, responsible for rehabilitation and recovery.

The mandate of the MOE for responding to environmental occurrences is currently confined to pollution incidents such as spills, leaks and releases of chemicals and petroleum products. The Ministry nevertheless has an important role in providing guidance, expertise and scientific and technical support in addressing the environmental aspects of disasters and the provision of advice on ecosystem rehabilitation and restoration during the recovery phase. This was particularly relevant in the case of the tsunami where district level structures were overwhelmed by the scale of the disaster and by the loss of staff, offices and equipment.

2.6 Conclusions and Recommendations

In its Notes on Reconstruction, BAPPENAS outlines three phases of post-tsunami recovery activities. The first six month period focuses on meeting urgent human needs and addressing livelihoods that have been lost due to damage to the natural environment. The second phase (6 months–2 years) concentrates on the rehabilitation of the damaged environment. The third stage is directed to the restoration of environmental conditions and services over the longer term (2–5 years) and consolidating progress towards environmentally sustainable development. The recommended BAPPENAS programme is backed up by the findings of the Banda Aceh REA conducted by the MOE.

The recommendations under thematic headings listed below are focused on activities to be implemented in the initial six-month period, although many will have a longer application. They take full account of the BAPPENAS recommendations in relation to guiding principles, and mainstreaming and restorative considerations. In all cases, processes must link with and feed information into the BAPPENAS planning process.

Rapid Environmental Assessments

A comprehensive audit of post-tsunami environmental impacts and needs would provide a sound knowledge base for medium-term planning and management of the environment and natural resources. Such an assessment would build on the initial rapid environmental assessments. It would provide a

geographic and textual information base to support spatial planning processes and be of use to reconstruction planning in the longer term. A comprehensive assessment of the environment would also promote the incorporation of environmentally sensitive criteria and principles into medium term spatial development plans.

The MOE requires continued international support to complete the planned REA process, focusing on Meulaboh, Calang, Pulau Nias, and on rural needs. The establishment of an environmental audit capacity within the MOE at the national and provincial level to support national, provincial and district planning is recommended.

Groundwater

Groundwater contamination is a clear and critical issue affecting the future well-being of survivors. Comprehensive groundwater assessments are required by the responsible national authorities to identify risks and alert local populations, as well as to identify alternative supplies. The initial focus of the assessment would have to be main population centres, but the assessment needs to be comprehensive in scope.

Sanitation

Sanitation is an ongoing challenge in all affected communities and IDP camps. One of the urgent priorities is to develop appropriate sewage facilities at population centres in the affected region. An immediate focus should be providing adequate facilities at temporary shelters, and sufficient latrines, built to recognized standards, at future settlements. In addition, an immediate draining and clearing of standing contaminated water bodies in and around settlement areas should be conducted. Technical guidance on sanitation pollution prevention and safe disposal should also be provided for local populations engaged in the reconstruction of houses.

Waste Management

International support to the local authorities in waste management is a critical need, as the volume of waste is enormous and the potential risks from hazardous wastes and other chemicals are unknown. The UNDP/OCHA pilot project in Banda Aceh should be implemented immediately, and replicated as soon as possible in other areas, if positive results are achieved. Waste projects should also promote and support localized waste management, including recycling and organic waste management initiatives. Practical guidance will also be needed on waste handling, re-use, and appropriate siting of waste facilities.

Agriculture and Fisheries

Agriculture and fisheries are the hardest hit employment sectors. There is an opportunity to mainstream environmental understanding and sustainable use within livelihood recovery, thus reducing future exposure to both environmental degradation and disasters. The need, underscored by FAO, is to replace fishing capacity in a way that is consistent with the fisheries ability to support sustainable fishing. In the case of damaged reef ecosystems, it may take some time for the system to recover. Care needs to be taken to rebuild fishing capacity in balance with ecosystem recovery.

During the recovery process, fishing communities must be engaged to the maximum extent possible in formulating and implementing restoration programmes for mangroves and wetlands. Extraction rates should be linked to resource replenishment capacity in general, and especially in the case of recovering ecosystems. A damaged tambak may be best replaced with the mangroves that it originally destroyed. Return to a traditional tambak design (versus modern intensive methods), integrating passive water flows and harmonizing with mangroves may allow both systems to co-exist.

Shelter

With the destruction of housing infrastructure, and the associated temporary shelter and planned settlements, a number of needs have been raised. Local authorities and other agencies must be given practical guidance in temporary settlement construction and management. Potential environmental impacts associated with the location, design and construction of proposed transit camps need to be taken into account. Following the closure of camps, appropriate clean-up operations and ecological rehabilitation must be undertaken.

Environmental Effects of Reconstruction

Proactive measures are required to avoid environmentally damaging effects associated with reconstruction (see special study on the timber issue). GOI and donors should note the findings of the 'Humanitarian Timber Taskforce" and associated activities proposed by WWF Indonesia and Greenomics, and ensure reconstruction materials come from sustainable sources, and not protected areas.

Integrated Coastal Zone Management

Vulnerability mapping needs to be incorporated into coastal zone management in order to determine exclusion zones for certain types of development, as well as for construction and building codes. The MOE should be immediately included in the BAPPENAS spatial planning group to facilitate the sharing of information on environmental vulnerability parameters, as well as other areas of environmental relevance. Strategies to engage communities in the rehabilitation process need to be incorporated within the broader planning processes as quickly as possible.

Prioritize Sites for Reconstruction

Coastal zones in the impacted area have been shown to be vulnerable to tsunami damage. Applying the precautionary principle, it is possible to design coastal buffer strips of between 250 and 500 metres, planted with appropriate mixed vegetation and utilizing earthworks where necessary, to establish a protective buffer against future tsunamis and potential vulnerability from sea level rise. While nothing can guarantee complete safety, a significant reduction in vulnerability can be achieved through an 'eco-engineering' approach. Coastal sites should be prioritized according to reconstruction planning needs, and this process should be embedded within the BAPPENAS reconstruction planning process.

Regional and National Early Warning Systems

Several meetings on an early warning system for the Indian Ocean have indicated that UNESCO/IOC should provide the initial leadership. Whether regionally or nationally based, the effective implementation of an early warning system will require significant focus at the national level in order for systems to be established and maintained, and should be accompanied by thorough community education programmes. An early warning process with public warnings should also be developed and implemented within the context of a national disaster management plan. Community based early warning principles and awareness should be established as part of a 'bottom-up' approach to disaster preparedness and response.

Disaster Management

Environmental management must be integrated with disaster response and recovery plans. As part of an improved audit capacity, MOE capacity must be strengthened in the areas of environmental disaster reduction, mitigation and response capacity, and it must have a clearly defined role within established national disaster management processes.

In consultation with relevant stakeholders, an office of the MOE in Banda Aceh should be established to support local and regional capacity in responding to recovery and rehabilitation needs. An important focus should be on strategies for enhanced public participation in decisions regarding environment and natural resource management.

Disaster awareness and preparedness can also be promoted at the community level. Educational materials currently available through UNESCO and the Indonesian NGO IDEP can be harmonized for introduction into school and community based training.

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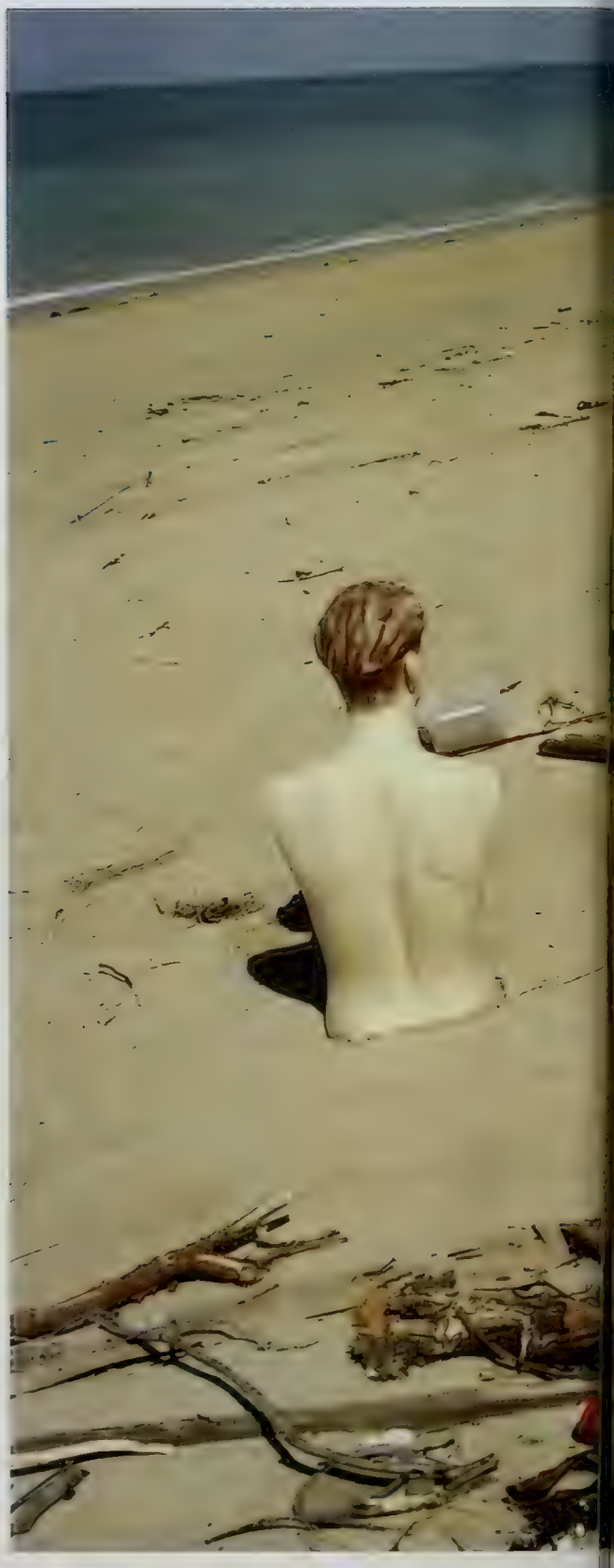
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THAILAND

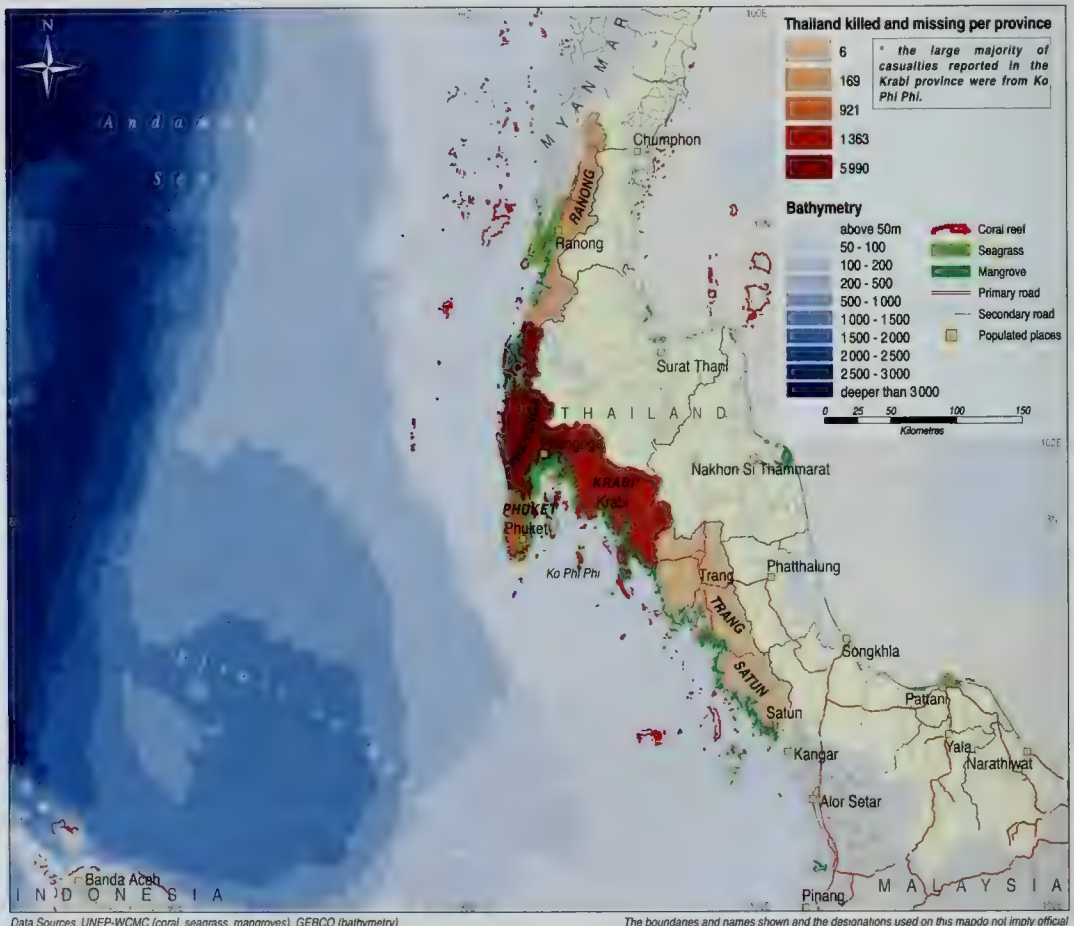


Khao Lak, Thailand (January 2005). With its benign climate, spectacular coral reefs and wealth of culture, Thailand attracts paradise-seeking tourists from around the world to its palm-fringed shores. On 26 December 2004, paradise was shattered. As well as killing more than 5,000 people and injuring many more, the tsunami had a severe impact on tourism, fisheries and agriculture. The livelihood of more than 50,000 people on the Thai coast has been directly affected. © Stuart Franklin/Magnum

3. NATIONAL RAPID ENVIRONMENTAL ASSESSMENT - THAILAND

3.1 Introduction

In Thailand, the tsunami hit the Andaman Coast (954 kilometres in length) between 9.40 and 10.30 a.m. local time. The first waves passed almost unnoticed four to ten kilometres offshore. The second series of waves, however, up to 10 metres high, impacted severely on the six coastal provinces along the Andaman Sea, namely: Ranong, Phang Nga, Phuket, Krabi, Trang and Satun. The level of devastation in the six provinces varies significantly depending upon a number of natural parameters including bathymetry, slope, elevation and presence of natural barriers, as well as man-made factors such as coastal land-use and development. The most affected province is Phang Nga, in particular Khao Lak district. Phuket and Krabi provinces were also severely impacted. In Ranong, Trang and Satun provinces, offshore islands sustained severe damage, but lesser impacts were recorded on the mainland. As of 8 February 2005, the Royal Thai Government casualty estimates were reported at 5,393 dead, 8,457 injured and 3,062 missing.



Data Sources: UNEP-WCMC (coral, seagrass, mangroves), GEBCO (bathymetry)
Thailand Health Ministry, WHO Public Health Mapping & GIS group and
UNEP/WHO Health and Environment Linkages Initiative (mortality),
NIMA VMap Level 0, UN Cartographic Section
Cartography: UNEP/DEWA/GRID-Europe, February 2005

The boundaries and names shown and the designations used on this mapdo not imply official endorsement or acceptance by the United Nations.

Immediately after the disaster, the Royal Thai Government mounted effective response operations to address urgent humanitarian needs, including the provision of food, clean water and shelter. An emergency fund was set up with an initial allocation of $2.5 million. Most relief operations were funded from the emergency fund and the government annual budget and carried out by government agencies with the support of the private sector and individual volunteers. The Thai Red Cross also played a vital role in coordinating the delivery of public donations to affected communities. With the immediate humanitarian needs largely met, the main focus shifted to environmental, psycho-social and livelihood restoration, care for vulnerable groups, and disaster preparedness.



Phuket, Thailand (31 January 2005). A young Thai lights candles during a vigil for tsunami victims on Patong beach in Phuket, one Thailand's popular tropical island resort destinations. © Bazuki Muhammad/Reuters

3.2 Overview of Environmental Response

Soon after the disaster, government agencies initiated rapid assessments of the impacts on most of the natural resources in the affected provinces. In particular, the Department of Marine and Coastal Resources of the Ministry of Natural Resources and Environment (MONRE), together with Thai universities and the private sector commenced impact assessments on coral reefs, sea grass and mangroves. At the same time, the Department of National Parks, Wildlife and Plant Conservation of MONRE investigated impacts on infrastructure and facilities in protected areas while the Department of Mineral Resources assessed land subsidence, coastal erosion and surface water quality. The Department of Health, of the Ministry of Public Health, began assessing groundwater quality and the Department of Fisheries of the Ministry of Agriculture and Cooperatives looked at impacts on fishing vessels and aquaculture infrastructure.

In addition, to help coordinate the support from the international community, the Government established a sub-committee on environmental and livelihoods rehabilitation as well as three task forces on coral reef and coastal habitats, geo-hazards and community livelihoods. MONRE is the lead agency

on environmental rehabilitation and geohazards, while the Department of Fisheries, Ministry of Agriculture and Cooperatives has been given a predominant role on livelihood rehabilitation, in particular regarding affected fishing communities.

The Government did not seek external financial assistance but requested support in terms of technical expertise, equipment and capacity building, in particular in the areas of environmental rehabilitation and community livelihood recovery. Short-term priorities include the clean-up of the affected coastal ecosystems, in particular coral reefs and beaches, to be completed by the end of March when the monsoon will set in. The Ministry of Natural Resources and Environment specifically requested UNEP expertise and support to carry out a rapid environmental assessment, and to prepare response plans and projects including development of an early warning system.

To respond to the requests from the Royal Thai Government, the United Nations (UN) organized three inter-agency assessment missions. From 28 December 2004 to 12 January 2005, OCHA sent a United Nations Disaster Assessment and Coordination (UNDAC) team to assess the emergency needs. A joint UNDP/World Bank/FAO mission was sent from 4 to 8 January 2005 to assess medium- and long-term impacts and possible partnerships in the areas of livelihood recovery as well as environmental rehabilitation.

A joint UNDP/UNHABITAT/ILO/IOM/UNHCR/UNESCO/UNEP mission was sent subsequently from 10 to 13 January 2005 to assess the needs of government agencies, civil society organizations and the people in the fields of shelter and resettlement, employment, environment, migrant workers and indigenous communities and knowledge. The environmental sector assessment was lead by UNEP.

Based on preliminary assessments made, the Flash Appeal for the Tsunami-affected countries included a joint UNDP/FAO/UNEP proposal of $900,000 for improved environmental restoration and increased awareness of the role of natural resource management for natural hazard vulnerability and for protection of valuable fishing and tourism resources.

The UN currently provides support to address short- to medium-term priorities, in particular in the field of provision of food aid to vulnerable groups, including children and migrant workers' families, provision of equipment and expertise for clean-up of coral reefs and support to most affected schools in terms of repair of infrastructure, school supplies and transport. A Tsunami Human Settlements Recovery Facility, with seed capital of $1,000,000 has been set up to support specific programmes in Sri Lanka, Indonesia, Somalia and Thailand. In addition, UNEP is providing technical expertise to MONRE to help in undertaking a rapid assessment of the environmental impacts of the earthquake and the tsunamis, as well as to identify long-term needs in the field of environmental assessment and rehabilitation. This report is the first phase report of that assessment.

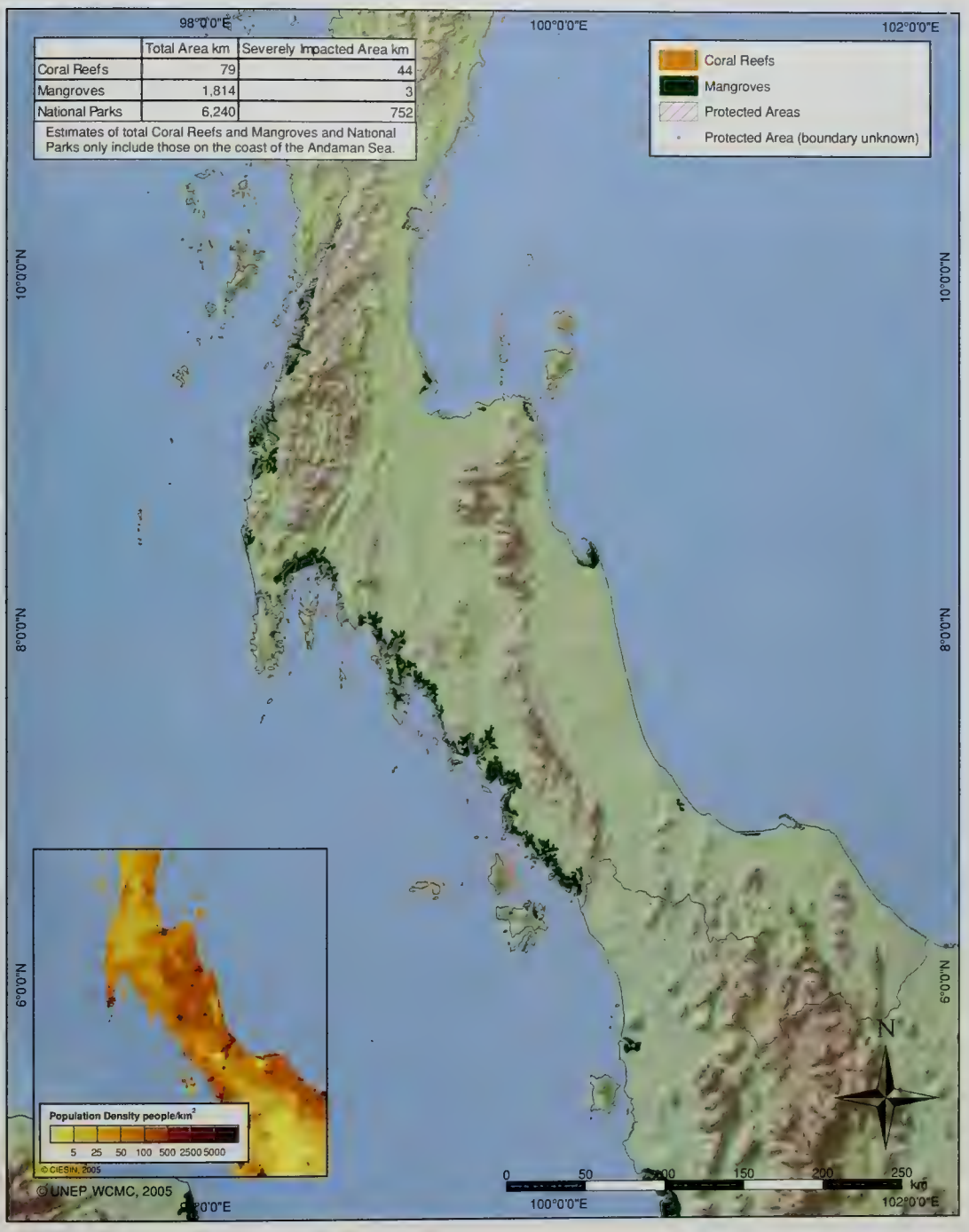
Close cooperation with key stakeholders has been paramount to the preparation of the rapid assessment report. The report is a desk study that relies extensively on field assessments undertaken by government agencies and Thai universities as well as on findings from field missions carried out by international organizations in coordination with government agencies.

3.3 Preliminary Findings: Impacts on the Natural Environment

Coral Reefs

The coral reefs along the Andaman coast of Thailand are a natural heritage characterized by a rich biological diversity. They are estimated to cover 7,861 hectares. The reefs are more developed around offshore islands while few reefs are located off the mainland. They are the main sources of direct income

Priority Ecosystems and Protected Areas in Thailand



	Total Area km	Severely Impacted Area km
Coral Reefs	79	44
Mangroves	1,814	3
National Parks	6,240	752

Estimates of total Coral Reefs and Mangroves and National Parks only include those on the coast of the Andaman Sea.

website: www.unep wcmc.org

please contact Kaveh Zahedi or Phillip Fox for further details

All data on Protected Areas, Coral Reefs, Seagrasses and Mangroves are available from UNEP WCMC databases.
Data on population density kindly provided by CIESIN.

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for tourism and indirect income for the fisheries sector. Thailand's coral reefs, however, have been deteriorating at an accelerating rate, particularly since the 1980s. The area of coral reefs assessed as either in good or very good condition has decreased from 34 per cent in the early 1990s to 16 per cent just before the tsunami.

To assess the impact of the tsunami, the Department of Marine and Coastal Resources, of MONRE undertook rapid assessments in 174 out of 324 coral reef sites with the support of eight Thai universities from 30 December 2004 to 15 January 2005. The 174 sites were selected across the six affected provinces inside and outside protected areas and include key snorkelling and diving sites as well as sites not visited by tourists.

The assessments reveal that approximately 13 per cent of the total coral reef area sampled has been significantly impacted. The level of impact is site-specific and varies from 0 per cent to 80 per cent. Coral reefs suffered from 10 to 80 per cent on islands' western coasts and 0 to 60 per cent on eastern coasts. Reefs located in channels between islands suffered higher impacts. Shallow-water reefs are most affected. Deep-water reefs and those around Phuket remain largely intact. Six to seven sites where over 50 per cent of the reef were impacted, may be closed to tourism, four of which are located in Mu Ko Surin National Park.

The type of impact observed is also site-specific and includes siltation and sand sedimentation and partial damage by debris swept away from land by the waves, as well as dislocation/removal of coral heads. This debris may prevent coral reef recovery and re-growth and present a threat from tidal action and wave pounding.

Sea Grass Beds

The sea grass beds along the Andaman coast of Thailand cover an area of 7,937 hectares. Sea grass habitats are of considerable importance as a basis for fishery production, as a food source for certain threatened animals, in particular the Green turtle (*Chelonia mydasand)* and the dugong (*Dugong dugon*), as well as for coastal stabilisation. Changes in sea grass area over the last decades have not been assessed, since the first comprehensive survey has only been completed recently. However, the main threats to sea grass are known and include pollution and sedimentation from industrial, housing and tourism developments, effluent from shrimp farms, disturbance from push and trawl net fishing, and siltation from tin mining.

To estimate the impacts of the tsunami disaster on the sea grass meadows, a rapid assessment was undertaken by the Department of Marine and Coastal Resources of MONRE covering approximately 70 per cent of the total sea grass area.

Based on the results, 3.5 per cent of the inspected areas are impacted, through siltation and sand sedimentation, while 1.5 per cent of the inspected areas suffered total habitat loss. The most impacted sea grass meadows are those of Yao Yai Island, Phang Nga Province, which registered an estimated total habitat loss of 10 per cent.

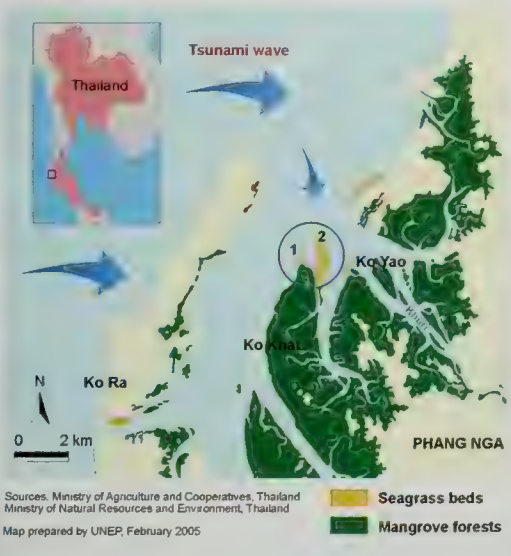
The sea grass meadows of Talibong Island, Trang Province, which are the largest sea grass areas in Thailand's Andaman coast providing foraging grounds to a large dugong population, did not suffer any total habitat loss, although 10 per cent of the area is impacted by siltation or superficial erosion.

It is estimated that it will take three months for sea grass to recover from siltation. However, it is not yet known how long it will take to recover from sand sedimentation. The assessments also revealed that sea grass meadows covering the inter-tidal zone appear to have prevented soil erosion of beaches during the tsunami event, such as at Kuraburi, Phang Nga Province (see Case study).

Case study: Sea grass buffering in Thailand

The tsunami caused significant geomorphologic changes along the coastline, such as eroding sand beaches and enlarging water channels.

Sea grass beds are known to help stabilize the coastline. In Khura Buri, in the severely impacted province of Phang Nga, sea grass beds appeared to have mitigated coastal erosion in the inter-tidal zones. This is illustrated by the sea grass beds in the mouth of the Khuri river (circled in blue on the map).





Khura Buri, Phang Nga Province,Thailand (2000). Sea grass beds in the mouth of the Khuri river before the tsunami disaster. © Department of Marine and Coastal Resources, Ministry of Natural Resources and Environment



Khura Buri, Phang Nga Province, Thailand (January 2005). Sea grass beds in the mouth of the Khuri river helped reduce coastal erostion in the inter-tidal zone, although they suffered from siltation and slight surface erosion. © Department of Marine and Coastal Resources, Ministry of Natural Resources and Environment.

Mangroves

Mangrove forests help stabilize banks and protect reefs from terrestrial sediments (see text box case study). They are home to a rich diversity of marine and avian wildlife and provide shelter among their roots for juvenile reef fish. The mangrove forests along the Andaman coast of Thailand cover an area of approximately 181,374 hectares. Changes in mangrove forest area cannot be precisely determined due to differences in the methodologies applied over time. However, the main threats to mangrove forests are known and include: infrastructure (roads) development, settlements, coastal aquaculture (up to the late 1990s), and the use of mangrove forest as landfills.

To estimate the extent of the damage caused by the tsunami to the mangrove forests, the Department of Marine and Coastal Resources of MONRE requested the 32 stations that manage mangrove forests on the Andaman Coast, to undertake rapid ground surveys.

The main findings are that only about 306 hectares of mangrove forests have been impacted, representing less than 0.2 percent of their total area. Most of the damage is located in Phang Nga Province with four stations reporting a total of 304 hectares affected. The remaining damage was reported at one station in Satun Province, where only 1.6 hectares was affected.

The beach forests (non-mangrove) along the Andaman coast of Thailand cover some 1,465 hectares. No rapid assessment has yet been conducted to investigate the impacts of the tsunami on those forests.

Protected Areas

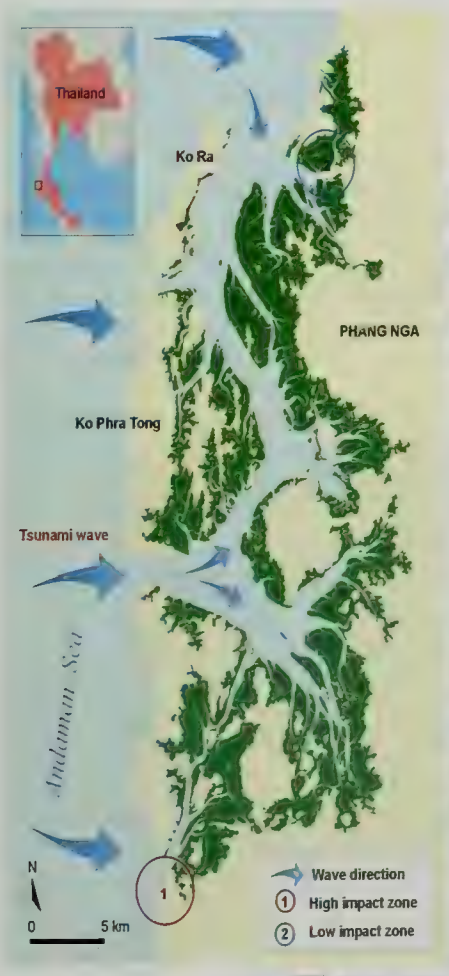
There are 14 Marine National Parks on the Andaman Coast of Thailand. They cover many of the archipelagic islands, including Surin, Similan, Phi Phi, Adang Rawi and Tarutao, as well as sensitive areas on the coastal mainland in each of the six tsunami-affected provinces. Marine National Parks are managed by the Department of National Parks, Wildlife and Plant Conservation (DNP), MONRE. Three of these marine national parks have been proposed to be listed as World Natural Heritage Sites.



Mangrove roots, Thailand (undated file picture). In Phang Nga, the most affected province of Thailand, large mangrove forests in the north and south of the province significantly mitigated the impact of the tsunami, reducing the energy of the waves and providing protection to inland habitats. © Bojan Brecelj/Still Pictures

Case study: Ecological benefits of mangrove forests

Mangrove forests are known to stabilize banks, protect reefs from terrestrial sediments, host a rich diversity of marine and avian wildlife and provide shelter among their roots for juvenile fish. They can also help protect coastal populations from tidal waves caused by natural phenomenon, such as typhoons and earthquakes. In Phang Nga, the most affected province of Thailand, large mangrove forests in the north and south of the province have significantly mitigated the impact of the Tsunami. They suffered damage on their seaside fringe, but reduced the tidal wave energy, providing protection to the inland population.



Source: Ministry of Agriculture and Cooperatives, Thailand
Map prepared by UNEP, February 2005



Khura Buri, Phang Nga Province, Thailand (January 2005). Small fishing village unaffected by the tsunami thanks to the protection of mangrove forests (location "2" on the map).



Phang Nga Province, Thailand (January 2005). Coastal area not protected by mangrove forests and severely impacted by the tsunami (location "1" on the map).

Beside damage to the marine and coastal habitats (described in the previous sections), Marine National Parks suffered losses in terms of infrastructure (office, housing, tourist facilities) and equip(communications, vehicles). Six Marine National Parks were most affected by the tsunami, including Laem Son MNP (Ranong Province), Sirinath MNP (Phuket Province), Mu Ko Surin MNP, Mu Ko Similan MNP and Tan Bok Korani MNP (Phang Nga Province), and Hat Noppharat Thara MNP (Phi Phi Islands, Krabi Province).

Marine Wildlife

Thailand's Andaman Sea hosts a number of threatened fauna species, including dugong (*Dugong dugon),* globally vulnerable, a number of species of dolphins; and four species of sea turtles: Leatherback turtle *(Dermochelys coriacea)* – critically endangered; Green turtle *(Chelonia mydas)* – threatened; Hawksbill turtle *(Eretmochelys imbricata)* – critically endangered; and, Olive Ridley turtle *(Lepidochelys olivacea)* – endangered. The main threats to sea turtles include coastal development, in particular massive tourism development, and fishing practices, such as entanglement and drowning in long-line fisheries and shrimp trawling nets. Some 150 dugongs are estimated to live in the Andaman Sea, in scattered groups from Ranong to Satun, with the biggest population around Trang's Talibong and Muk islands. The incidental catching of dugongs in nets and the degradation of sea grass meadows are the two main threats to dugongs.

The tsunami disaster affected significantly four sea turtle conservation projects. The Turtle Conservation Project (Phang Nga Province) lost two project staff and the project camp was totally destroyed. The Tap Lamu Naval Base (Phang Nga Province) where the breeding/conservation centre is in ruins and around 2,000 turtles are reported to have been lost. The Phuket Marine Biological Centre lost 18 breeding Olive Ridley turtles. Finally, the Sea Turtle Conservation and Wildlife Sanctuary Project (Ranong Province) with participating communities is also reporting heavy impacts and damage. In addition, two dugongs and three dolphins were carried inland by the waves. One of the dugongs and two of the dolphins died.



Dugong feeding on sea grass (undated file picture). The sea grass beds along the Andaman coast of Thailand cover an area of 7,937 hectares. Sea grass habitats are important for fisheries and as grazing areas for marine fauna, such as the Green turtle and the dugong. Sea grass meadows covering the inter-tidal zone appear to have prevented soil erosion during the tsunami. © Kelvin Aitken/Still Pictures

Surface and Groundwater

The tsunami flooded coastal areas up to two to three kilometres inland. In the inundated area, surface waters are likely to have been contaminated significantly with sea water. The Department of Mineral Resources of MONRE carried out an assessment of the impact of sea water intrusion into surface water bodies. Of the thirty water bodies sampled as of 1 February 2005, 29 face significant contamination and can no longer be used as they were prior to the tsunami.

Short duration flooding is likely to have caused negligible infiltration of saline water into groundwater. However, water that remained in pools, lakes or depressions after the tsunami, could lead to saline infiltration, especially in areas with permeable soils and sediments, hence impacting on groundwater. In addition, the destructive force of the tsunami has removed coastal sediments resulting in a landward shift of the coastline in some areas. The intrusion of sea water in the coastal aquifers is expected to shift landwards over a similar distance. which may affect some nearby groundwater wells. In the longer term, salinization of groundwater might also occur by deposited salts leaching from unsaturated zones into the groundwater. The problem of groundwater quality is further compounded by the potential contamination from sewage and the large amount of waste generated by the tsunami.

The Department of Health, Ministry of Public Health analysed the quality of well water in the six tsunami-affected provinces for coliform bacteria, chlorine, and suspended matter. The contamination of well water in Phanga Nga Province is significant. The water in 187 out of 530 wells is unsafe due to coliform bacteria contamination and in 32 out of 534 wells it is unsafe due to sea water intrusion. However, the condition of these wells prior to the tsunami is not well documented. In Phuket, coliform bacteria contamination affected 55 wells severely and 44 slightly. The quality of the water in twelve of these wells has already been restored with the addition of chlorine.

Soils

In the inundated zone, deposition of salts is expected to have occurred, which in turn might affect the vegetation cover and the medium to long-term fertility of the soil.

Based on preliminary assessment, the Department of Mineral Resources, MONRE, estimated that 20,300 hectares of land on the mainland were inundated. It is estimated that about 1,505 hectares of agricultural land have been severely affected.

Land Subsidence

Land subsidence, in particular the formation of sinkholes, is a natural phenomenon known to occur in Thailand in areas with a limestone substrate. Over time, water dissolves the limestone and forms caves. The stability of the roof of the caves depends on a number of factors, such as the proximity of a fault or the hydrostatic pressure of the underground water. Strong vibration, such as earthquakes, can trigger the collapse of unstable or weakened caves. Sinkholes are usually not frequent. However, between the earthquake of 26 December 2004 and 24 January 2005, 25 sinkholes have been reported, an unprecedented frequency; 17 of them were reported in the six tsunami-affected provinces.

Sinkholes have not caused any casualties, but have damaged infrastructure. Two schools had to be closed. The Department of Mineral Resources of MONRE is currently mapping vulnerable areas.

3.4 Preliminary Findings: Impacts on the Human Environment

Infrastructure of Key Economic Sectors

The tsunami disaster heavily affected the infrastructure of the main economic sectors of the Andaman Coast, in particular the tourism and the fishing industries. It also impacted the agricultural sector. The losses in these three sectors are estimated at $321 million, $43 million and $0.65 million respectively.

Some 315 hotels and resorts and 234 restaurants have been totally or partially destroyed. In addition, some 4,306 shops, many of them largely dependent on tourism, have been lost. About 148 large tourist vessels and 776 small tourist boats have been damaged or lost.

In 2000, the total fish production in Thailand was estimated at 3.7 million metric tonnes, with 31.7 per cent of the total marine catch taken in the Andaman Sea, valued at $1.1 billion. Following the tsunami, the fishing industry, including coastal aquaculture, suffered major losses in terms of fishing vessels, fishing gear, culture ponds, cages and shrimp hatcheries. In addition eight harbours have been severely damaged. A summary of the impacts is provided in table 1.

The agricultural sector has also been impacted with 1,505 hectares of agricultural land severely contaminated with saline water and a loss in livestock estimated at 1,124 cows, buffalos, goats or sheep, 2,030 pigs and 7,667 poultry birds.

Table 1. Impacted fisheries infrastructure

Affected equipment	Extent of losses or damage
Fishing vessels	
Large fishing vessels	1,137 vessels
Small fishing boats	4,228 boats
Fishing gear	
Pushing nets	3,313 fishermen affected
Stake traps	683 fishermen affected
Bamboo traps	2,537 fishermen affected
Coastal aquaculture	
Culture ponds	11 ponds
Cages	5,977 fishermen affected
Shrimp hatcheries	277 hatcheries



Khao Lak, Thailand (9 January 2005). Workers take a break from cleaning up a tsunami-hit shrimp farm. Coastal aquaculture in Thailand suffered major losses, as did the fishing industry, with heavy damage to fishing vessels, fishing gear, culture ponds, cages and shrimp hatcheries. © Andrew Wong/Getty Images

Solid and Liquid Waste

With the extensive damage to the built environment, including individual houses (6,791 damaged and 3,619 destroyed), shops, tourist facilities and public infrastructure, large amounts of debris ranging from inert building material to hazardous wastes were generated. The total amount of debris is not precisely known, although preliminary estimates for Phi Phi Islands (Phang Nga Province) are at 30,000 to 35,000 tonnes of which 13,000 tonnes have already been collected. With the powerful action of the receding waves, debris was scattered across the coastal zone from the settlement areas to the beaches and into the marine ecosystems such as sea grass meadows and coral reefs.

Clean-up operations are ongoing in 66 locations in five provinces. Debris is disposed on temporary sites and sorted. The Ministry of Interior has provided $887,500 for the procurement of nine incinerators (six in Phang-Nga Province and three in Krabi Province) to dispose of hazardous wastes. In addition, a treatment plant has been installed in Phang Nga Province, to take care of the hazardous wastewater generated by the forensic operations.

In the vicinity of urban settlements, debris brought by the receding tidal waves is one of the most pressing threats to the marine ecosystem and needs to be removed rapidly to prevent irreparable damages. Since 9 January 2005, the Department of Marine and Coastal Resources of MONRE in close collaboration with the Department of National Parks, Wildlife and Plant Conservation of MONRE, and many actors from the private sector have been conducting regular clean-up operations of the beaches and the coral reefs starting with Phuket and Phi Phi Islands, two major tourist destinations. The Department of Marine and Coastal Resources intends to complete the clean-up of all affected coral reefs and beaches by the end of March, just before the onset of the monsoon season.

Case Study: Waste clean-up partnership in Thailand

The tidal waves brought large amounts of debris onto the coral reefs, in particular in the vicinity of urban areas and tourist resorts. The clean-up of coral reef is on the Royal Thai Government's top priority list.

To complete such delicate operations in all affected reefs by end of March before the onset of the moonson season, stakeholders form all sectors are joining efforts. For Phi Phi islands, for example, they include:

1) Government agencies:
 - MONRE (coordination, diving team and equipment);
 - Tourism Authority of Thailand (public relations);
 - Thai Navy (diving teams and equipment, boats to transport debris).
2) Local authorities:
 - District administration (trucks to transport debris to disposal sites)
3) Private sector:
 - Thai Airways (transport Bangkok – Krabi)
 - Krabi Tourism Association (transport of participants by ferry)
 - Diving Association (diving team and diving equipment)
4) International and government donors:
 - United Nations (provision of equipment for clean-up)
5) NGOs and civil society:
 - Wildlife Thailand Fund (WTF) (volunteers)



Patong, Phuket Province, Thailand (15 January 2005). As part of the coordinated clean-up operations, large and small debris being lifted to the surface to prevent further damage to the coral reefs. © Department of Marine and Coastal Resources, Ministry of Natural Resources and Environment.

Water Distribution and Irrigation

There has been no report of major water distribution disruption in the six affected provinces. However, water was found contaminated with coliform bacteria or chlorine in a significant number of wells in Phrang Nga and Phuket province as mentioned above.

Energy

The infrastructure supporting the distribution of electricity has been damaged by the tsunami, affecting 5,148 customers. Most of the repair work has been completed, costing some $4.2 million.

3.5 Preliminary Results: Environmental Management Capacity

The Environmental Protection and Quality Act of 1975 was the first framework environmental legislation in Thailand. It was replaced in 1992 by a more comprehensive and detailed act: the Enhancement and Conservation of National Environmental Quality Act. The Act provides, inter alia, for environmental quality standards, conservation and protected areas, pollution control and enforcement, access to information and research. The Act also established a National Environment Board that shall prepare a policy and plan for enhancement and conservation of the environment. The Environmental Protection and Quality Act (1992) also provides criteria and procedures to conduct EIA, as well as the EIA report requirements. Some 500 EIA reports are prepared yearly of which around 20 per cent are approved without conditions. The EIA process, however, suffers from some weaknesses, which have led the Minister of Natural Resources and Environment to appoint a special committee to review it entirely. It is expected that a revised EIA process be in place in 2005

Several pieces of sectoral legislation have been enacted that are directly relevant to the management of the coastal and marine resources. These include the National Park Act (1961), the Forest Act (1941), the National Reserved Forests Act (1961), the Fishery Act (1994), the Harbour Act (1913 and 1992), and the Wildlife Preservation and Protection Act (1992). There is a current need to review and streamline these legislations in order to support an integrated coastal zone management approach.

Coastal Zone Management

Coastal zone management in Thailand was first attempted in the 1980s with the establishment of the Coastal Development Division under the Department of Land Development. Its broad objective was to provide guidelines for coastal development based on soil characteristics. Lack of guidance on how to integrate the work of the division with the other government agencies, however, led to closure of the division. Meanwhile, major developments have taken place in the coastal areas, making coastal zone management more a tool for resolving land use conflicts than a tool for holistic planning that takes into account the needs of all stakeholders.

Early Warning

No early warning system was in place to issue an alert and mitigate the impact of the tsunami, despite Thailand's membership of the Pacific Tsunami Warning System. Following the disaster, several countries and international organizations have made proposals for the establishment of a regional early warning system. As no consensus among the proponents has yet arisen on the host of the centre, the Government of Thailand announced the establishment of a national early warning system and encouraged collaboration between their proposed system and the regional early warning system when it is finally agreed upon.



Phuket, Thailand (28 January 2005). Ministers and representatives of the Ministerial Meeting on Regional Cooperation on Tsunami Early Warning Arrangements pose for a group photo in Phuket, Thailand. No early warning system was in place to issue an alert and mitigate the impact of the tsunami, despite Thailand's membership of the Pacific Tsunami Warning System. © Bazuki Muhammad/Reuters

Disaster Management

A Department of Disaster Prevention and Mitigation is currently operating within the Ministry of Interior. The Department has the mandate to lead the coordination of all government relief efforts in tsunami-affected provinces. To date, the Department has established a database to support decision-making, management, monitoring and follow-up programmes. The database includes data on casualties and damage and information on ongoing government relief efforts, in particular with regard to relief unemployment plans, relocation of communities and tourists.

Following the earthquake and the tsunami, the Prime Minister allocated specific mandates to various government agencies to manage the disaster. Four national committees on emergency response, natural resources, livelihoods and disaster management and early warning, were established to coordinate the response of the government on those priority issues.

3.6 Conclusions and Recommendations

Rehabilitation of Natural Resources

Very large amounts of debris were generated and scattered over the marine and coastal ecosystems, in particular coral reefs, beaches and sea grass meadows. The clean-up of these ecosystems is on the Government's top priority list and is currently the main focus of the rehabilitation work. Clean-up operations have been on-going since 9 January 2005 with coordination by the MONRE and with substantial support from the private sector and international organizations. The target is to complete the clean-up by the end of March before the onset of the monsoon season.

In the medium-term, it is estimated that these ecosystems will recover naturally from mild impacts, such as siltation, in particular during the monsoon season. Long-term rehabilitation work will require

detailed impact assessments and should be guided by systematic monitoring. To conduct the required detailed assessments in a timely manner and to ensure a close monitoring of the health status of the affected marine and coastal resources, there will be a need for technical expertise, equipment and capacity building, in particular in the field of methodologies, survey techniques, geographical information system (GIS) and remote sensing.

Livelihoods Recovery

The tsunami impacted severely on the main economic sectors in the coastal provinces of the Andaman Sea, namely tourism, fisheries and agriculture. The livelihoods of well over 50,000 people have been directly affected.

There is a compensation scheme for damage or loss of fishing vessels, loss of fishing gear and loss from aquaculture holdings. The level of compensation is based on fixed rates for each type of damage or loss. However, those rates may not compensate fully for the incurred losses. Additional support at the village level is required to enable a prompt livelihood recovery of the fishing communities. A large number of the lost fishing gear, such as stake traps, were illegal. There is a window of opportunity to introduce more sustainable fishing practices and economic incentives. There is also a need to devise and implement a strategy to procure the necessary material to rebuilt houses and repair vessels, in particular wood products. This would prevent wood coming from illegal or unregulated exploitation of the mangrove and other coastal forests.

To support tourism recovery, clean-up operations started with the most affected tourist destinations. In addition, major promotional campaigns have been initiated to rebuild tourist confidence. There is a risk that a fast track recovery of the tourism industry may lead to a rapid rebuilding of the infrastructure that existed before the disaster. Such an approach would pre-empt an integrated coastal zone management plan which is now absolutely essential to reduce human vulnerability to natural disasters and ensure long-term sustainability.

Integrated Coastal Zone Management

The vulnerability of the Andaman Coast, in particular in Phrang Nga, Phuket and Krabi provinces, to natural disasters is clearly linked to land use and coastal development planning. Following the failed attempt of coastal zone management in the 1980s, little attention has been given to integrated coastal zone management. If anything positive can be gained from the disaster, it is clearly the opportunity it offers for integrated coastal zone management (ICZM). To be effective, ICZM, being a cross-cutting issue, must be initiated at the early stage of the recovery process, as highlighted in the discussions of the three task forces, recently established, on coral reefs and coastal habitats, geohazards, and community livelihoods.

Early Warning

Following the disaster, quite a number of proposals for the establishment of a regional early warning system were developed. In addition to such a regional system, much attention should also be given to enhancing the capabilities of the coastal population in foreseeing the occurrence of natural disasters and preparing for them. Knowledge acquired by traditional communities, from observations and from scientific research on the tsunami and other natural disasters should be used to educate vulnerable coastal communities, in particular through school curricula.

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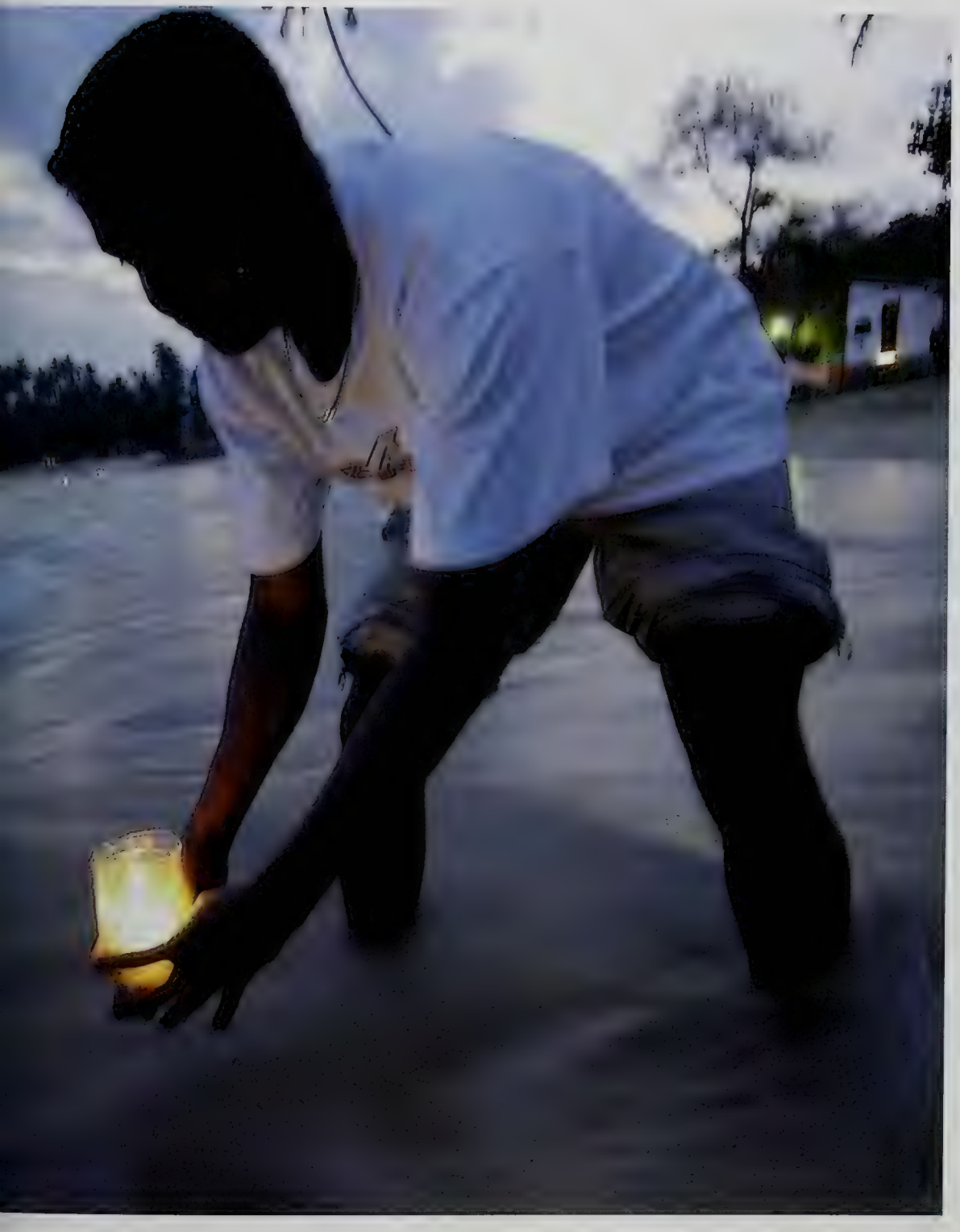
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SRI LANKA



Galle, Sri Lanka (26 January 2005). A Sri Lankan man places a lit earthenware lamp in the sea at Unawatuna Beach in Galle, some 123 kilometres south of the capital, Colombo. Sri Lankans lit some 40,000 lamps in memory of those killed by the tsunami. The Sri Lankan Centre for National Operations lists 30,957 dead and 5,637 missing.
© Prakash Singh/AFP/Getty Images

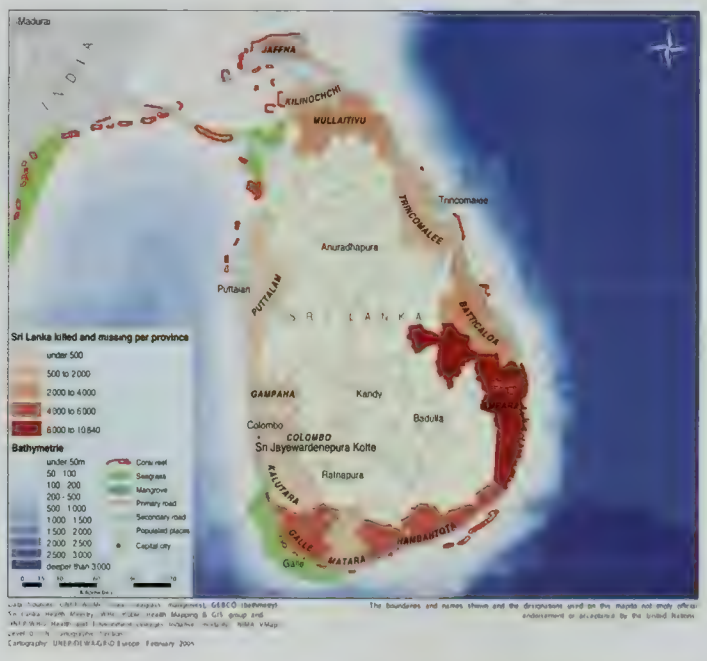


4. NATIONAL RAPID ENVIRONMENTAL ASSESSMENT – SRI LANKA

4.1 Introduction

The first tsunami wave began to impact the eastern coast of Sri Lanka about 100 minutes after the earthquake, at approximately 8:40 a.m. The wave surge was recorded at between 5 and 6.5 metres in most of the eastern and northeastern coast, and parts of the southern coast, doing most damage up to 3 metres above mean sea level. A secondary wave struck approximately 20 minutes later.

The complex interaction between water-borne energy, sea-bed and terrestrial terrain meant that the effects of the tsunami were different from place to place, but in general the eastern, north-eastern and south-eastern coast of Sri Lanka were particularly hard hit. Overall, the tsunami affected two-thirds of the coastline of Sri Lanka, over 1,000 kilometres in total. Seawater penetrated from tens to hundreds of metres inland (in places thousands of metres), and typically drained away within 30 minutes. During that time, between 31,000 and 37,000 people were killed by drowning or debris impact, and nearly 100,000 houses were destroyed along with tens of thousands of vehicles and much infrastructure. About 27,000 fatalities were fishermen, and two-thirds of the nation's fishing boats were wrecked, destroying many jobs. Farming was affected by the incursion of large amounts of salt water and marine sediment to fields and wells. Tourism was suspended in the middle of its peak season, and many coastal hotel rooms were destroyed and additional jobs lost.



A state of emergency was declared in all 12 of the affected coastal districts, and the national emergency and security services deployed rapidly. In the north and east an active role was also taken by the Liberation Tigers of Tamil Eelam (LTTE). The President moved swiftly to appoint three national task forces to lead and coordinate the response of the line agencies, these being the Task Force for Rescue and Relief (TAFRER), the Task Force for Logistics and Law and Order (TAFLOL), and the Task Force for Rebuilding the Nation (TAFREN). Many national initiatives have since been taken, ranging from the announcement that a restricted construction zone would be demarcated on the ground 100–200 metres from the coast,



Seenigama, Sri Lanka (26 January 2005). A Sri Lankan woman sits among the rubble of her house destroyed by the tsunami as aid workers help clear debris at Seenigama Village, some 90 kilometres south of the Sri Lankan capital Colombo. © Prakash Singh/AFP/Getty Images

to measures to relieve hardship such as confirmation that the salaries of civil servants killed in the disaster would continue to be paid to what would have been their retirement age and full pension rights guaranteed thereafter.

The donor community and government reacted quickly to the tsunami disaster and deployed many teams to assess various dimensions of damage, the need for restoration and recovery, and opportunities to improve the circumstances of affected peoples.

4.2 Overview of the Environmental Response

The Government of Sri Lanka, through its Ministry of Environment and Natural Resources (MENR), quickly requested urgent assistance from UNEP to work with national experts in conducting a rapid environmental assessment (REA) of the damage caused by the tsunami. Environmental issues specified for assessment included coral reefs, shore erosion, coastal land use planning, water pollution, and soil contamination. The Government further specified that its top priority for UNEP after the assessment was in developing a forward-looking plan for coastal zone management, in which lessons learned from the disaster would be adequately incorporated.

The UNDAC mission that was launched in Sri Lanka on 26 December 2004 included a UNEP-OCHA environmental expert, who focused on acute environmental problems with immediate and direct relevance to human lives and welfare. Based on the initial information collected, UNDP and UNEP submitted a project proposal to the UN Flash Appeal for $3,000,000 to undertake short and medium term measures for the assessment and recovery of natural resources and livelihoods.

The planning phase of the REA began with the deployment of senior UNEP staff to Sri Lanka on 5 January 2005. By 17 January 2005, the South Asia Co-operative Environment Programme (SACEP) agreed to provide logistical services in support of the UNEP REA team. Meanwhile, the MENR and Central Environmental Authority (CEA) had defined methods for the REA based on contracting teams from four universities (Moratuwa, Ruhuna, Eastern and Jaffna), supported by other sources of expertise, to undertake a field analysis of tsunami impacts on 'green' (ecosystem and biodiversity impacts) and 'brown' (pollution, debris and impacts on human settlements and infrastructure) aspects of the environment. A UNEP adviser arrived on 19 January 2005 to provide additional technical expertise to the assessment.

The REA is being prepared in coordination with various donor agencies, both bilateral (e.g. the Netherlands and Sweden) and multilateral (e.g. World Bank, ADB and JBIC). It relates to the stated needs of the Government of Sri Lanka, as well as to the work of the special Task Forces appointed by the President of Sri Lanka in the aftermath of the disaster, especially TAFREN.

An Advisory Committee comprising senior government officials and academics, and including UNEP, was appointed by MENR to oversee the REA, and approved its methods on 3 February 2005. The timeline for the REA is as follows:

(i) data collection from 7 February to 18 March 2005.
(ii) compilation of findings from 18-31 March 2005.
(iii) final report preparation from 1-18 April 2005.

The Advisory Committee is scheduled to meet on 25 February 2005 to review progress, and around 18 March 2005 to review findings.

The CEA, using funds from the Government of the Netherlands, is conducting its own parallel studies with an emphasis on solid wastes. All assessments are being conducted under the strategic oversight of the Advisory Committee chaired by MENR and including senior officials of the CEA, Department of Wild Life Conservation, Marine Pollution Prevention Authority, Ministry of Fisheries and Oceanic Resources, Coast Conservation Department, National Aquatic Resources Research and Development Agency (NARA), Forestry Department, Tourist Board, Urban Development Authority, and others including UNEP.

In terms of NGO activities, IUCN, CORDIO, Global Coral Reef Monitoring Network, and the Sri Lanka Sub Aqua Club are undertaking with NARA an assessment of impacts on coral reefs in the east, south and southwest, and of impacts on other coastal ecosystems in the south.

To date, information sharing has been effective, and this interim report is based on numerous studies addressing a range of sectors and sub-sectors, including those prepared by The Government of Sri Lanka and donor agencies, as well as others commissioned by UNEP. As a result, there are few gaps in absolute coverage, although more detail is needed and is now being collected as a basis for reconstruction planning.

4.3 Preliminary Findings: Impacts on the Natural Environment

The Coastal Zone

Sri Lanka has a coastline of approximately 1,660 kilometres (the range reported is 1,585–1,730 kilometres). The coastal zone is very diverse, and contains lagoons and estuaries, fringing and offshore reefs, mangrove swamps, seagrass beds, salt marshes, beaches, sand spits, rocky shores and dune systems. Sri Lanka's coastal zone contains very productive ecosystems that sustain a large proportion of the country's people and flora and fauna.

Priority Ecosystems and Protected Areas in Sri Lanka



	Total Area km²	Potential Area Impacted km²
Coral Reefs	671	671
Mangroves	87	87
Protected Areas	12,545	1 887

website: www.unep-wcmc.org

please contact Kaveh Zahedi or Phillip Fox for further details

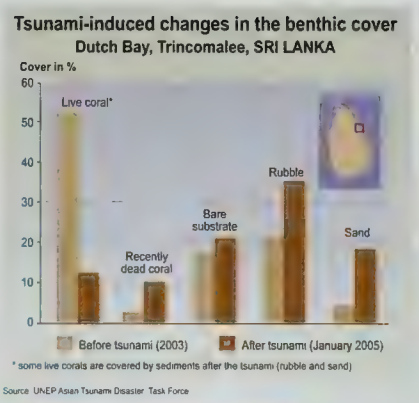
All data on Protected Areas, Coral Reefs, Seagrasses and Mangroves are available from UNEP-WCMC databases.
Data on population density kindly provided by CIESIN.

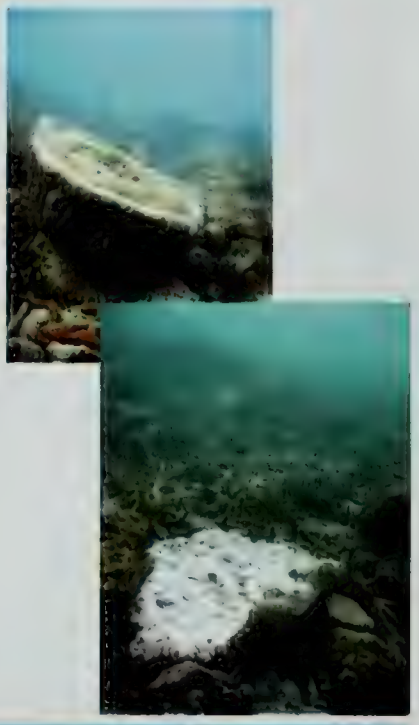
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Case study – Destruction of a coral reef in Dutch Bay, Trincolamee

Trincomalee was almost exactly due east of the central part of the tsunami disturbance. Prior to the tsunami, Dutch Bay had a coral cover of about 50 per cent, mostly made up of branching *Acropora* and foliose *Montipora*, interspersed with massive Faviid and Poritid colonies. Observations after the tsunami showed that the reefs had been virtually destroyed:

- Extreme mechanical damage, with nearly half of the coral reef area ripped off, including the reef base (limestone substrate) in some places, turning the reef into fields of rubble and sand. Three quarters or more of the remainder has also been severely damaged.
- Large coral blocks and dead coral have been moved over the reef, tearing off the live coral and also the reef base. The southern reef margin has been restructured and severely eroded.
- Granite rocks and boulders 20–50 centimetres in diameter have been shifted, particularly around a rock patch near the shore.
- Virtually all remaining live corals had been damaged, and many *Acropora* colonies have been sheared. Among standing thickets, most branches were loose and moving with the swell. Many table corals had been uprooted and toppled over.
- Many massive colonies have been toppled, including some *Porites* domes over two metres in diameter, and many colonies of about 50 centimetres have shifted large distances.
- A lot of broken branches of live coral are being abraded in moving rubble beds. Many coral colonies were partially or entirely buried in rubble and sand.
- There were also signs of paling and bleaching in remaining massive colonies, most notably *Goniastrea* sp., *Porites* sp. and *Favia* sp. This may be caused by sediment stress and abrasion.
- Many soft corals were found ripped off the reef substrate and with severe tissue damage.
- There was very little evidence of litter, debris and sediment from land sources.







Coral Reefs

The greatest extent of true coral reef is located in the Gulf of Mannar in the north-west, off the southern coast and the eastern coast near Trincomalee. There are extensive areas of patch reefs at Bar Reef in the north, Great and Little Basses in the south, and off the eastern shores. There are fringing, patch and platform reefs elsewhere around the country including sandstone/limestone and rocky reef habitats, covering in total about 680 square kilometres. Their diversity is high with as many as 190 species of hard corals and over 300 species of fish, including as many as 35 species of butterflyfish (*Chaetodontidae*).

The coral reefs of Sri Lanka were far from pristine prior to the *tsunami*, since in many areas they had been all but destroyed by the mining of coral rock for making lime and cement. Also, reefs had been heavily exploited for living resources while management intervention was generally inadequate. Blast fishing and purse seining were continuing, even in reef areas designated for protection such as the Pigeon Island National Park in Trincomalee, and the Bar Reef and Rumassala Marine Sanctuaries. The 1998 bleaching event also had a profound effect on the western and southern coral reefs, while the damage was less on the eastern coast, and many areas had not recovered when the tsunami struck.

Surveys by NARA, IUCN and others are continuing, or are awaiting improvements in the weather. As of mid February, coral reefs had been surveyed at five sites in the south and southwest (Kapparatota-Weligama, Polhena, Unawatuna, Hikkaduwa and Rumassala), and at one site in the east (Dutch Bay, Trincomalee). The tsunami moved enormous boulders and sections of reef, as well as thousands of tonnes of smaller fragments, sand and silt, which dislodge, abrade, crush and kill marine biota. There was also a powerful backwash carrying large quantities of waste, debris, soil and organic matter. Despite all this, damage to reefs was very patchy, ranging from total destruction in some areas to almost no impact in others, reflecting a complex interaction among the recent history and condition of the reef, with the precise way the tsunami energy was delivered to that particular environment. Some smothering was observed, but it appears primarily from re-suspended marine sediments rather than by matter intruding from the land. Litter and debris is abundant. Much of the rubble formed after the mass mortality of corals in 1998 has shifted.

Severe damage on the coast was observed where coral mining in the sea had been rampant in the past. There were signs of absorbed impact and less damage in locations with healthier vegetation and less disturbed ecosystems.

Mangroves

Mangroves are a rapidly diminishing wetland type in Sri Lanka, consisting of less than 10,000 hectares of discontinuously distributed patches along the coastline. The most extensive mangrove areas are in Puttalam district, with over 2,000 hectares. Batticaloa and Trincomalee districts also have extensive mangroves, each with over 1,000 hectares. Unfortunately, the inherent productivity of the tidal ecosystem combined with poor tenure arrangements in coastal environments that are neither land nor sea, has meant that mangroves are vulnerable to conversion by private investors, especially into prawn ponds. This has happened to a considerable degree in western Sri Lanka, where up to half of naturally-occurring mangroves are said to have been lost, but the position is unclear in eastern parts of the country where the war has inhibited both investment and monitoring.

Although mature mangroves are typically very resistant to water surges, and in many areas were apparently unaffected by the tsunami, there are limits to this resilience and in some areas large mangrove trees were uprooted and lay toppled far from the beach. Quantitative information on the extent of damage is not available at the time of writing, but an indicative sample of the impacts of the tsunami upon a range of coastal ecosystems, is provided in the case study.

Case study – Tsunami impacts on special management areas in Sri Lanka

Seven Special Area Management (SAM) sites were affected by the tsunami: Negombo, Lunawa, Maduganga, Hikkaduwa, Habaraduwa, Mawella and Kalametiya (see Table). Although detailed, quantitative data are not yet available, inspection of these sites provides an indicative sample of the impacts of the tsunami upon a range of coastal ecosystems, including lagoons, mangroves, beaches, sand dunes, reefs, canals and farmland, in the southwestern and southern coastal areas. Examples from four sites are listed below.

Environmental damage at SAM sites

SAM site	Key environmental impacts
Negombo	• The channels in the lagoon mouth have been deepened by the tsunami. • The six canals connected to the lagoon have been blocked by debris. • The beaches are polluted with debris and rubbish. • There has been little damage to coastal vegetation such as mangroves. • The sand dunes in Morawalla, Sethapaduwa and Thalahena have been damaged. In some places these dunes used to be about 15 metres high but have now been eroded. Coastal vegetation on the dunes has been affected. • A substantial amount of debris has been deposited inside the lagoon.
Lunawa	• The mouth of Lunawa lagoon was swept open by the tsunami. • The water level in the lagoon decreased. After a few days the lagoon mouth closed again. • Beaches within the SAM area are being polluted by rubbish that is being dumped there. This is especially plastic, wood and solid waste. Although some beaches are being cleaned, many beaches are polluted with debris and rubble. • The coastal vegetation has been severely damaged. Even some coconut palms have been destroyed indicating the force of the water. • Although Lunawa Lagoon is one of the most polluted lagoons in the country, the tsunami does not seem to have brought in large amounts of debris and rubbish.
Maduganga	• The physical structure of the mouth of Maduganga lagoon has not changed, but the sandbar blocking the lagoon from the sea was swept away and the southern bank was lightly damaged in places. • Due to the tsunami a large amount of debris entered the lagoon and is still inside the water body. • Several boats sunk inside the lagoon. Some of them have not been reclaimed and are still under water. • Due to the complete opening of the lagoon mouth, salinity inside the lagoon has increased. The high salinity of the water in the lagoon could result in salt water intrusion into paddy fields. • In several places the coastal vegetation has been damaged.
Mawella	• Groundwater polluted with salt water, resulting in unusable wells. • The Mawella canal and the Moreketiya lagoon are heavily polluted with debris and rubbish; there is a large amount of vegetation and organic material inside the Moreketiya lagoon. The canal is now open but blocked by debris. • The beach in the SAM area is polluted with debris and rubbish.

Sea Grass

Sea grass beds constitute the most extensive coastal ecosystem in Sri Lanka. They occur along the open coast as well as within estuaries and lagoons (UNEP-WCMC, 2003). Very large beds exist around the north-western and southwestern coasts, and smaller sea grass beds are found on the leeward side of coral reefs elsewhere. Sea grass beds are important as feeding and breeding grounds for fish, as well as stabilizing submerged sand banks.

Damage to sea grass beds was minor and was mostly due to shifting rubble; hardly any uprooting was observed. Severe beach erosion was observed both in the east and southwest, but was patchy in its occurrence.

Biodiversity and Protected Areas

Sri Lanka is the most biologically-diverse country in Asia per unit area, and about half its native species are endemic. It lies on a major bird migration route and provides critical habitat to many migratory waterfowl. The island is also critical habitat for many internationally-mobile species, including five species of endangered marine turtle (the Loggerhead *Caretta caretta*, Olive Ridley *Lepidochelys olivacea*, Hawksbill *Eretmochelys imbricata*, Green *Chelonia mydas*, and Leatherback *Dermochelys coriacea*). In part to preserve this rich biodiversity, Sri Lanka has officially declared 146 National Reserves or protected areas covering about 9,926 square kilometres, or 15.3 per cent of its land area; while forest reserves of 5,182 square kilometres and proposed forest reserves of 6,211 square kilometres cover another 17.2 per cent of the land area. However, much of the biodiversity is concentrated in the wet zone, which is poorly represented in the protected area system with only one strict nature reserve, one national park, and one wildlife sanctuary.

At Yala and Bundala National Parks, vegetated coastal sand dunes completely stopped the tsunami, which was only able to enter where the dune line was broken by river outlets. At one outlet in Yala National Park considerable damage was done to park facilities (with a number of human deaths) as well as to forest and grassland, with many trees uprooted and the vegetation largely dead and brown. Two other sites in the park had damage up to 1.3 kilometres inland in flat areas. Less than 1 per cent of the park area was affected by the tsunami in total. Natural recovery is expected as salt levels are reduced, assisted by high rainfall since the tsunami. Some damaged areas of the parks may be recolonised by alien invasive species such as prickly-pears (*Opuntia*) and the salt-tolerant mesquite (*Prosopis juliflora*). There has been no documented loss of fauna in the protected areas affected by the tsunami, as most birds and the larger mammals managed to avoid being caught in it (though dead mouse deer, monitor lizards and soft-shelled terrapins have been reported from the south coast.

The Coast Conservation Department manages eight Special Area Management (SAM) sites, of which seven were affected by the tsunami. The case study provides indicative information on a range of impacts.

4.4 Preliminary Results: Impacts on the Human Environment

Human Settlements

A number of factors increased the vulnerability of human settlements to the tsunami in Sri Lanka. Among them are the historical absence of building standards, construction that was uninfluenced by a tradition of risk aversion because of a perceived absence of major natural disasters, a lack of city planning and zoning regulations, and a resulting haphazard pattern of construction. Other aggravating factors included weak local government institutions with poor response capacities for the provision of basic urban services, poor access to services by most people resulting in the need to find on-site solutions for solid waste, drinking water and sanitation, and high densities in unplanned settlements. These factors combine to undermine standards in the built environment of Sri Lanka even at the best of times. Largely



Galle, Sri Lanka (14 January 2005). Debris is seen everywhere in downtown Galle, Sri Lanka, where small shops were reduced to rubble by the 26 December Asian tsunami. © Paula Bronstein/Getty Images

bypassed by the mainstream development process, the poor in particular have found themselves living in informal, illegal and unhealthy conditions, often located in the most vulnerable zones. Such conditions make the poor, and particularly women and children, more vulnerable both to daily stresses and to natural disasters.

Around 12 per cent of all building units in Sri Lanka were located in administrative divisions along the Sri Lankan coast that were affected by the tsunami. Most houses are owner-occupier, with only 13 per cent of houses occupied by tenants. A typical house in the coastal zone of Sri Lanka has a single-floor, on-ground structure with shallow foundations, cement and burnt-brick walls, and wooden roof supports under tiles or 'cement asbestos' roofing sheets. Most had some form of septic tank, an electricity connection and access to some form of protected or safe drinking water. There were many more modest dwellings, with unfinished floors, wattle and daub, plank or palm leaf walls, and simple roofing, without in-house toilets, water and/or electricity. Within about 500 metres of the coast, the tsunami destroyed 99,500 houses and damaged another 46,300, a total of 13 per cent of the entire housing stock of the coastal divisions of the affected districts.

In addition, the destruction of public buildings means the loss of legal records, mortgages and other details. Banks are now faced with customers who have lost everything. Small market places (*pola*) and grocery shops have been destroyed, along with means of transport, ranging from bicycles and three-wheelers, to buses and lorries. Many of the affected families and businesses, having lost their savings which were held in jewellery or cash, do not have money and cannot start rebuilding their livelihoods. Workers who should be in high demand (such as boat builders, carpenters, cement brick producers) have lost their tools, and also face a clientele that has lost everything. Fishermen cannot pay boat builders in advance to enable them in turn to buy new tools, as they need boats to start earning money. Damaged cottage cement industries too cannot satisfy demand; and sand and cement prices have already started to increase.

Waste and Debris

The extent of debris, particularly from destroyed buildings, is enormous. Calculation of the weight of an average house in Sri Lanka yields a figure of about 7,000 kilograms of brick, cement and roofing material for well-built ones and 2,000 kilograms for a cruder 'fisherman's house'. Since the latter were far more vulnerable than the former, both in terms of location and strength, an average among the almost 100,000 homes destroyed might be about 3,000 kilograms, or 300 million kilograms in total, to which would need to be added the weight of debris from 43,600 damaged houses as well as lost household goods and furnishings, shops, tens of thousands of vehicles and boats, fallen trees, destroyed roads, bridges, culverts, etc., a total that must have exceeded another 200 million kilograms in addition and perhaps far more. The disposal of these 500+ million kilograms of rubble and waste material is proving to be a huge issue because of the sheer volume and associated costs. Emergency efforts have resulted in haphazard disposal of rubble along roads, in open fields, into drainage ditches, low lying lands and waterways, including beaches. This is likely to cause long-term problems by clogging waterways and polluting beaches. Burning of debris is also evident in certain areas but impacts air quality, and the CEA has ordered it stopped. The CEA has also instructed that solid wastes be collected and deposited in open areas such as playgrounds until proper sites for disposal are identified.

Water and Agriculture

Most people in rural Sri Lanka rely on wells for their drinking water, yet all dug wells in areas where the tsunami intruded, an estimated 62,000 of them, are now contaminated by sea water, and often by wastewater and sewage as well. This is an especially serious problem in Trincomalee, Amparai, Batticaloa



Kalmunai, Sri Lanka (3 February 2005). Checking the water purification machine in Sri Lanka's eastern town of Kalmunai. A 200-member Canadian military contingent is conducting relief operations on the east coast, providing clean drinking water for 80,000 tsunami survivors. © Prakash Singh/AFP/Getty Images

and Hambantota districts. The pipe-borne water supply system in the coastal areas is also largely out of service. These factors together undermine public access both to drinking water and to water for irrigation. Wells can be pumped out and chlorinated, but in some areas aquifers have also been contaminated which must be diluted and leached back to purity over months or perhaps years of rainfall. Initial surveys show that rice fields in the eastern districts of Trincomalee and Batticoloa have been heavily damaged. These rice fields produce more than one-third of the country's total harvest. The extent of crop damage may have been underestimated in reports to date, since salt has affected several thousand rice and fruit farms, and has dried to form a crust on the soil in many areas, leading to concerns that the fields will be unusable for many months until rains naturally reduce salinity. Fortunately, the seasonal rains have been heavy since the tsunami.

Transport Infrastructure

The damage to roads is in excess of 2,500 kilometres of the national, provincial and local authority road network, representing over 5 per cent of the national roads and 2 per cent of other categories of roads. Most of these roads, however, had previously been degraded through decades of under-investment. Damage to ports, harbours and anchorages was significant, with affected harbours at Kirinda, Tangalle and Kudawella in Hambantota, at Puranawella, Mirissa, Galle and Hikkaduwa in Matara, at Beruwela and Panadura in Kalutara, and at Cod-Bay in Trincomalee. A total of 37 major anchorages and thousands of minor landing sites were damaged. Several rail corridors were affected by the tsunami: in the north-eastern corridor (China Bay to Trincomalee), tracks were damaged; in the eastern corridor (Valachchanai to Batticaloa), tracks and a bridge were damaged; and in the southern corridor the portion between Colombo and Kalutara suffered minor damage that was quickly repaired, but beyond Kalutara 40 kilometres of track was slightly damaged, 20 kilometres were moderately damaged and 4 kilometres were severely damaged. Damage also occurred to embankments, track work, bridges and culverts, signaling and communication systems, buildings and rolling stock. The most dramatic injury to the railway system occurred when the tsunami overwhelmed a passenger train on this southern portion, with the deaths of some 1,500 passengers. Sri Lanka Railways carry about 28 million passengers annually, most of them commuters, and over half are now enduring significant hardship due to the absence of rail services in the southern corridor, which are not expected to be restored before May 2005.



Hikkaduwa, Sri Lanka. The 26 December tsunami overwhelmed a passenger train in southern Sri Lanka, killing some 1,500 passengers. Over half are now enduring significant hardship due to the absence of rail services in the southern corridor, which are not expected to be restored before May 2005. © Shehzad Noorani/Still Pictures

Industrial Sites

Little damage was caused to large-scale manufacturing industry since very few industrial facilities were located in the affected area. A large number of home-based production and income generating activities have been destroyed, however, affecting in particular women and artisans, and reducing family incomes.

Medical and Psychological Impacts

Health care services lost some 44 health institutions, including a large obstetric and gynaecology teaching hospital, many district hospitals, rural clinics, and units attached to dispensaries. There were associated losses of medical officers, equipment, drug stores, district health offices and about 54 vehicles, including ambulances. Another 48 health institutions were partly damaged with loss of medical instruments, and equipment. This sudden reduction in capacity coincided with an equally sudden increase in demand for medical services among survivors locally and displaced people elsewhere.

Since no part of the affected coastline was connected to a sewerage network, toilets were basic, with better housing both in cities and villages dependent on septic tanks. The tsunami damaged septic tanks by flooding, breaking and dislodging them and also dislodging a large number of traditional pit latrines, polluting the environment generally and water sources in particular with human excreta. There is also concern over the adequacy and safety of sanitation facilities provided to over 150,000 people still living in about 320 welfare centres.

Victims were buried in scores of mass graves, with the aim of protecting public health, even though bodies do not in fact pose much risk of infectious disease, since diseases and putrefaction are caused by different microorganisms. Mass graves also mean that relatives will never know what happened to their loved ones, which can cause long-term distress, and the procedure can also delay the certification of death with implications for insurance claims and other legal processes.

Impacts on Livelihoods, Poverty and Gender

Increased poverty is potentially the most important effect of this natural disaster. The macroeconomic impact of the tsunami is expected to be worse in Sri Lanka than in any other affected country apart from the Maldives, but the macro-level of analysis conceals a much more sinister impact on the livelihoods of the poor. Fisheries, tourism, trade, agriculture and artisanal or cottage industries provided most of the livelihoods in the affected areas, and all have been severely impacted. The worst effects of the tsunami were experienced by people living in weakly-constructed and unplanned settlements close to the shore, women and children deprived of bread-winners, and those with marginal livelihoods as cottage artisans. A large number of home-based production and income generating activities were destroyed, affecting women in particular, and reducing family incomes. The catastrophe could drive around 250,000 more people below the poverty line, and these numbers could increase if concerns over basic needs are not properly and quickly addressed.

Fishing and related small-scale food processing were affected the most by the disaster. Of the country's 29,700 fishing boats, about two-thirds were destroyed or significantly damaged, along with outboard motors, ice storage units, fishing gear and nets. Entire fishing communities were dependent on these fleets. Damage to the agriculture sector included the destruction of standing crops and home gardens, washing away of tree crops, and entry of sea water to productive fields which may render them unusable for many months. An estimated 27,000 jobs in the tourism industry were suspended by the tsunami, one third in officially-registered hotels and the rest in unregistered hotels and guesthouses. Many small businesses and informal traders catering to the tourism industry, (e.g., dive, souvenir, handicraft shops, and internet cafes) were damaged and are now facing a sustained period with far fewer customers. The main tourism season of January to March is likely to be lost entirely.

People suddenly impoverished by these impacts are likely to place unprecedented pressure on the environment. There are reports, for example, that unusually large numbers of nesting marine turtles have been killed for meat in Sri Lanka since the tsunami, as people strive to off-set an under-supply of fish protein. The extent of such collateral damage will depend to a large extent on how the recovery process is managed. In the fisheries sector the indiscriminate replacement of boats and fishing gear with new and high-quality equipment could easily result in over-exploitation of the marine environment. Similarly, welfare, relief and reconstruction programmes, unless well managed, could lead to wasteful consumption. Poor targeting, over-design of facilities and wasted investment will result in higher resource demand, depletion of natural resources and the generation of wastes, all having direct and indirect impacts on the environment.



Mirissa, Sri Lanka (5 January 2005). A Sri Lankan man walks past the wreckage of a fishing boat tossed ashore by the tsunami in the southern coastal town on Mirissa. As many as 27,000 of the fatalities were fishermen, and two-thirds of Sri Lanka's fishing boats were wrecked, destroying livelihoods for many families. © Jimin Lai/AFP/Getty Images

Impacts of Reconstruction

Demand on natural resources, including new land and changes of land use, will naturally increase during the reconstruction process. Initiatives to impose a resettlement zone, to re-plan, re-develop and relocate cities, and to introduce new roads, railways and port developments can only aggravate these pressures. Government initiatives to undertake a series of 'mega' projects in the wake of the recovery will add to this demand, all heating up the construction market with inevitable consequences for the exploitation of natural resources. Although elasticity in the supply of building materials could be handled by increasing

imports, an increase in prices is expected, which will encourage supplies, particularly timber, to be obtained from illegal sources. Mining of shore and river sand is already controlled, to some extent, but alternatives such as washed sea sand and quarry sand are in short supply, and with increased demand people may resort to illegal sand mining. The increased demand for bricks will likely lead to the removal of clay from productive paddy lands and the felling of trees for firewood. A sustained programme to improve production techniques, introduce alternative and low cost building materials, and research on improvement of traditional building technologies will help in mitigating such risks.

4.5 Preliminary Results: Environmental Management Capacity

The main government directly agencies involved in managing ecosystem resources in Sri Lanka, comprise the Department of Wild Life Conservation (DWLC), the Forestry Department and the Marine Pollution Prevention Department in the Ministry of Natural Resources and Environment (MENR), and the Coast Conservation Department (CCD) and National Aquatic Resources Research and Development Agency (NARA) in the Ministry of Fisheries and Oceanic Resources. Additional regulatory responsibilities lie with the Central Environmental Authority (CEA). A national *Coastal Zone Management Plan* prepared in 1990 and revised in 1997 and 2004, gives strategic direction to the Coast Conservation Department, identifying needs, ways and means to protect the country's coastal resources.

Institutional capacity for environmental management was barely sufficient for routine tasks, and is likely to be severely challenged by the new demands placed on the country by the tsunami disaster. Particular areas where capacity may need to be strengthened include documentation and analysis of tsunami and other impacts on ecosystems, monitoring of the condition of ecosystems, and the assessment and management of environmental impacts associated with reconstruction and resettlement.

The NARA Research Station was badly damaged, along with its research vessels, fleet of six rescue vessels, its radio room and its Fisheries Training Colleges and associated equipment. This will reduce its capacity to build capacity in the sustainable management of fish stocks for some time.

An early reaction of the The Government of Sri Lanka to the tsunami was to propose limiting construction and habitation near to the coast, including consideration of a possible restricted construction zone (RCZ) within 100 metres (150 metres or 200 metres in some areas) of the mean high tide line. Applying such a policy to large areas of densely-settled coastline would have profound implications for the economy, the environment, livelihoods (especially for those connected through fisheries and tourism to the sea and beach), and poverty. Plans for a Strategic Environmental Assessment to assess this matter are being developed by the MENR and CEA in concert with the Government of the Netherlands.

4.6 Conclusions and Recommendations

Protective Capacity of Ecosystems

Intact coral reefs, vegetated dune systems, deep stands of mangrove forest and other natural barriers, as a first line of defence, appear to have afforded significant protection to the coast beyond them. This is being investigated in detail by the REA assessment teams, but is consistent with the knowledge that reefs and mangroves are robust, structurally complex ecosystems that are able to absorb wave energy, and that sand dunes bound by roots are much more resistant to water and wind than is bare sand. If Sri Lanka still possessed as many natural defences as it did before its sand dunes and coral reefs had been mined, then the tsunami may have done far less damage.

Strengthening the Resilience of the Coastal Zone

An obvious conclusion from the foregoing is that the reconstruction of defensive ecosystems around the coast would be a good idea, and this is the single highest priority for the medium to long term. Some locations are not so easy to defend. Many bays suffered devastating property damage, probably because the tsunami was funnelled and strengthened by the shape of the sea bed and surrounding land, while river outlets through dune systems inevitably allowed the wave access to lagoons and inland areas. Meanwhile, the broad, flat beaches and hinterlands of the north-east offered an easy path deep inland for the tsunami surge, and it is hard to imagine how it could have been stopped entirely. A comprehensive process for strengthening the resilience and productivity of Sri Lanka's coastal zone will involve a number of measures applied in various combinations in various locations. As the coast is very heterogeneous in terms of terrain, natural ecosystems, and human pressures, there will be no one solution that can be applied in all places. Instead a number of options are available, including:

- **Relocating settlements**: some locations may be inherently indefensible except at extremely high cost, suggesting that they should be placed off-limits for construction and habitation.
- **Redesigning new construction**: buildings with open pathways for the passage of sea water, and that are well-made, seemed to be more resistant to damage during the recent tsunami than others; it is possible that adjustments to building codes may therefore be helpful where construction is to be permitted.
- **Building artificial breakwaters**: sea walls and harbour moles can break the power of waves and wind, but are expensive to build and maintain so cannot be used to protect a whole coast line; they may however be used to protect sites that are of sufficient value to justify the expense.
- **Establishing sand dunes**: natural dunes, if high and deep enough, and stabilised by vegetation, are able to stop major waves and did so in the recent tsunami incident; many areas may therefore benefit from the establishment or re-establishment of seaward dune systems.
- **Planting mangroves**: a deep enough band (>20-30 m) of mangrove vegetation can absorb considerable amounts of wave energy and protect the coast beyond, while also sustaining very productive fisheries; mangroves tend to grow in and around tidal mud-flats, estuaries and lagoons.
- **Using other vegetation types**: sea grass beds, coconut groves, *Casuarina* stands, *Pandanus* hedges, and other coastal vegetation types need to be assessed for utility in promoting resilience against disaster.
- **Establishing artificial coral reefs**: core structures, such as bundles of concrete pipes or wire cages filled with stones or rubble, may be sunk in shallow water, cabled together and anchored to resist currents; once conditioned by sea water, the structures will be colonised by reef organisms, a process of reef establishment that can be hastened by transplanting fragments of branching corals, juvenile giant clams, etc. onto the core structure.
- **Establishing marine protected areas**: experience in the Philippines and elsewhere has shown that even small areas set aside by communities and protected from fishing and other forms of damage can regenerate quickly and sustain a return to natural levels of fish diversity and productivity, which is useful both for fisherfolk and in terms of attracting recreational and educational visitors; the protected areas form a network of colonisation sites that speed up other interventions, such as the restoration of coral reefs.

None of these measures can provide a perfect defence against all extremes of natural disaster, and even intact mangroves, coral reefs and coastal dunes were damaged in places by the tsunami in Sri Lanka. Closer to the epicentre, in the Andaman-Nicobar archipelago and around northern Sumatra, such damage is reportedly extensive. Much can nevertheless be achieved through a realistic, cost-effective strategy of strengthening the coast against environmental shocks. A locally-appropriate selection from among the

options listed would need to be made by local stakeholders based on a thorough understanding of the local environment, prior to implementation by local authorities (Municipal/Urban Councils and *Pradeshiva Sabha*) supported by technical and other resources provided by the government and civil society. Ecological reconstruction initiatives would best be fully integrated within local renewal or recovery plans that also address investment in livelihoods, infrastructure, settlements, communications, government and other services.

Knowledge Exchange and Early Warning

As Sri Lanka reviews its coastal zone management and development plans in the light of lessons learned from the tsunami, it would be wise as well to find out as much as possible about the manner in which other tsunami-prone and typhoon-prone countries in the Asia-Pacific region undertake coastal zone planning. Various governments have been working for some time on ecological restoration in their coastal zones. These include Hainan Province of China, and Tamil Nadu State of India, which have planted *Casuarina* shelterbelt forests as a defence against typhoons, and Vietnam and Indonesia, which have planted substantial areas of mangroves. Practical knowledge on what works can be made accessible to Sri Lanka through exchange visits and study tours with these countries. Since other countries affected by the tsunami may also conclude that they need to take similar measures in their own coastal zones, sharing of relevant knowledge would increase the effectiveness of the whole regional process, with benefits for each country.

Digital Terrain Mapping in Coastal Zone Planning

Horizontal zoning based on distance from the mean high tide line has limitations as a planning tool for the coastal zone from the point of view of seeking to increase its resilience to waves and storm surges. The tsunami penetrated onshore to a very variable extent, depending largely on terrain, with flat areas without coastline defences being most extensively inundated. Hence it would be desirable to commission a detailed digital terrain map of the coastal zone, between the 50 metre terrestrial contour and the -50 metre submarine contour. This will inform choices about where certain kinds of coastline defence should be situated, and the justification for different levels of investment in different areas. The economic value of a large, low, flat area containing farmland or infrastructure, for example, might justify considerable investment in strengthening its coastline defences, whilst a narrow area bounded by steep land might not.

Reconstruction Standards

Housing represents by far the most valuable asset lost by the affected families. For most, it also represents the asset they most want to repossess with least possible delay. This will lead to intense pressure for rapid construction in the affected districts. Policies should promote safe building, and higher but affordable design standards. It should be noted that virtually no framed house will withstand a direct sideways hit from a tsunami, as the waves can deliver about a 1,000 tonne lateral force. However, consideration of building stilted houses on concrete piles could be an option. Investing in higher quality and risk reduction are as important as the need to address the potential threats of an unmanaged demand on limited natural resources that could accompany a rapid reconstruction process. The same applies to some of the social and economic infrastructure, particularly tourist hotels and related buildings which in the past have violated basic norms of environmental safety. Besides building in hazardous and ecologically sensitive locations, they have also been responsible for extensive pollution of the beaches, waterways, mangroves and estuaries through discharge of sewage, solid waste and excessive disturbance of ecosystems. Critical buildings such as schools, hospitals, and emergency response facilities should be built well away from any vulnerable locations.

Debris and Waste Management

The systematic and environmentally-friendly disposal of the construction debris is a major challenge, made worse because the local authorities in most affected areas do not provide a solid waste management service, and therefore lack relevant capacity and technical knowledge. Of those few bigger cities that do have the knowledge, none has an engineered landfill. The need therefore is to find creative and innovative responses to the problem. One step would be to encourage, and perhaps pay people, to salvage recyclable and re-saleable materials such as steel reinforcement rods, timber and bricks. This process has been initiated by people themselves in some areas and should be promoted more widely, giving families more time to salvage useful material for resale or for rebuilding their houses. Managing the large volumes of residue needs expert guidance. Engineered landfills are a possibility, and other suggestions include using building debris as base material for road construction, and in building sea walls, and dunes, an artificial coral reefs, and community refugee mounds.

Debris management and waste disposal is a significant weakness in the international response to disaster. A possible approach is to motivate, mobilize and equip local people in the immediate aftermath of disaster through the immediate delivery of goggles, masks, boots, gloves, sacks, guidance manuals in local languages, and money with which to hire able-bodied people. Mobile laboratories equipped to detect contamination by the most dangerous chemical families would also be useful in such circumstances.

Local and/or community radio stations can help to augment the flow of locally-relevant information, and pre-recorded audio tapes may provide early information content and guidance to affected people.

Mainstreaming Environmental Perspectives

Ways should be sought to achieve far greater mainstreaming of environmental considerations both in planning and implementing the reconstruction, and in the development process as a whole. There should be ongoing review of all policies, laws and institutions to ensure that adequate attention is paid to the environment at all times. While one focus would be to review national laws that govern activities in the coastal zone itself, there are other laws and regulations at national, provincial and local levels that impinge upon natural resource management, housing, construction and infrastructure development. These would need to be aligned with the policies, processes and programmes of the post-tsunami response plans, including a stronger emphasis on public participation. Such a review should be implemented as soon as possible by an inter-ministerial team with the appropriate legal support. It should be accompanied by capacity building at both the central and the local levels of society. Urgent discussions should focus on ways in which a thorough and comprehensive overhaul of Sri Lanka's capacity for environmentally and socially sustainable development can be accomplished. Some areas that could provide an immediate focus include:

- **Building capacity at MENR and CEA**. The capacity of these institutions may be exceeded by the need to conduct environmental impact assessments prior to planning and constructing new settlements, and monitoring events hereafter.
- **Building capacity at MPCLG and local authorities**. The capacity of these institutions may be exceeded by the need to integrate activities to strengthen coastal resilience within plans developed and implemented by local stakeholders.
- **Environmental education and awareness**. A process is needed to increase public understanding of the environments where communities live, so that they can be encouraged and enabled to participate in their own development, including ecological reconstruction.
- **Completion of a detailed environmental assessment**. There remains a need to analyse 1,200 sites on vulnerability, physical, ecological and social damage, land use, etc., and to use observations to model in detail wave behavior and apply lessons to the mitigation of future tsunami-like shocks.

- **Regional knowledge sharing**. The quality of Sri Lankan development planning would be enhanced through exchange among experts and institutions that have experience of ecological reconstruction, planning and construction of sustainable urban environments, use of digital terrain mapping to guide investment in coastline defence, and in waste management.

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THE MALDIVES



Hakura, Maldives (10 January 2005). An aerial view of the damaged Hakura resort in the Maldives, along a flight path taken by the UN Secretary-General, Kofi Annan, who travelled to the region. At least 23 of the 87 tourist resorts in the Maldives were devastated in the 26 December tsunami. © Sena Vidanagama/AFP/Getty Images



5. NATIONAL RAPID ENVIRONMENTAL ASSESSMENT – THE MALDIVES

5.1 Introduction

The Indian Ocean tsunami reached the Maldives at 9:20 a.m. local time, approximately three hours after tremors were felt. Tidal waves ranging between one and five metres high were reported in all parts of the country. The force of the waves caused widespread infrastructure devastation in the atolls, 80 per cent of which are less than one metre above sea level.

On a per capita basis, the Maldives is one of the countries worst affected by the tsunami. Sixty-nine islands of the country's 199 inhabited islands were damaged (out of a total of approximately 1,190). Twenty were largely devastated, and 14 had to be evacuated. Approximately 13,000 internally displaced persons are either homeless or living with friends and relatives on other islands. In all, nearly a third of the country's 290,000 residents have suffered from loss or damage of homes, livelihoods and local infrastructure.

The tsunami had a substantial impact on the national economy, which depends largely on nature tourism, fishing and agriculture. Flooding wiped out electricity supplies on many islands, destroying communication links with most atolls. All communications were lost for ten hours or more on 182 islands, and four islands still have no direct communication. Electricity supplies in many affected islands are yet to be restored. Water supply was disrupted in approximately 15 per cent of the islands, and 25 per cent of the islands experienced major damage to essential infrastructure such as jetties and harbours that link the islands with the outside world.



Kolhufushi Beach, Maldives (10 January 2005). Young tsunami survivors play at a relief camp. On a per capita basis, the Maldives is one of the countries worst affected by the tsunami. Sixty-nine of the country's 199 inhabited islands were damaged, and 14 had to be evacuated. Approximately 13,000 internally displaced persons are either homeless or living with friends and relatives on other islands.
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5.2 Overview of the Environmental Response

Within hours after the tsunami struck, the Ministry of Environment and Construction (MEC) joined an inter-ministerial task force organized by the President of Maldives, H.E Maumoon Abdul Gayoom. At the same time, the MEC developed a questionnaire that was used to call affected islands and assess the extent of damage to water, sanitation, waste, coastal and other environmental infrastructure.

A request was then made by the Ministry, on behalf of the Government of the Maldives (GOM), to the Joint UNEP/OCHA Environment Unit to assist the Ministry with the environmental emergency caused by the tsunami. On 28 December 2004, an environmental expert arrived in Maldives and undertook a rapid assessment of the tsunami's environmental impacts as a member of the United Nations Disaster Assessment and Coordination (UNDAC) team. On 3 January 2005, based on the findings of the UNEP/OCHA rapid environmental assessment, the MEC requested UNEP's further assistance with the country's environmental recovery and reconstruction work, in particular in addressing waste management issues. A total of $950,000 was included in the UN Flash appeal to cover environmental assessment and waste management activities.

A UNEP waste management expert was deployed on 10 January to provide immediate technical assistance. At the same time, UNEP began providing environmental inputs to external assessments, including World Bank-Asian Development Bank-UN System Joint Needs Assessment as well as developing project proposals with MEC on waste management, clean-up and comprehensive environmental assessment.

Throughout all stages of the response, UNEP has worked in close cooperation and partnership with the MEC. For purposes of the environmental assessment and the work to follow, the MEC convened an inter-ministerial environmental task force comprising representatives from the National Disaster Management Centre, Ministry of Tourism, Ministry of Fisheries, Agriculture and Marine Resources, Maldives Water and Sanitation Authority, Department of Meteorology, Environment Research Centre and the Marine Research Centre. The task force has informed and supported the rapid environmental assessment process. The Ministry of Communication, Science and Technology provided additional assistance by sharing its own assessment of tsunami impacts.

Other important assessments and activities in the environmental sector were divided between a number of national and international actors. An interdisciplinary team sponsored by the Australian government (AusAID) studied the tsunami's impacts on coral reefs. All results from this survey have been shared and good cooperation has been achieved. A number of actors are also in the process of conducting (or have completed) geological, geomorphologic and vulnerability assessments including USAID-U.S. Geological Survey, the Japanese Society of Civil Engineers/JICA, the Coalition of Australian Universities and the International Oceans Commission. UNICEF, Oxfam, the International Federation of the Red Cross and the US Army have run emergency water and sanitation relief programmes, while WHO is focusing on health care waste management. UNDP is developing disaster risk reduction activities, while FAO is focusing on soil and groundwater investigation as well as fisheries sector assistance.
Teams of environmental specialists at the MEC worked in close cooperation with UNEP to collect available information from on-going activities in order to develop this preliminary impact overview. The above-referenced inter-ministerial environmental task force advised the process and commented on draft text. MEC teams consulted relevant pre-tsunami baseline documentation and gathered available information about the tsunami's impact on each of several environmental and cross-cutting issues.

A number of limitations in data gathering were identified, including (i) inadequate pre- or post-tsunami data on the Maldives environment; (ii) a lack of geographic information system (GIS), satellite imagery or other visual information; (iii) the absence of an official tsunami impact assessment; (iv) the general lack of environmental monitoring and reporting at the atoll or island level; and (v) logistical obstacles to inspecting impacted areas.

5.3 Preliminary Findings: Impacts on the Natural Environment

Groundwater

Groundwater aquifers in the Maldives islands normally lie at a depth of between 1 and 1.5 metres below the surface. Aquifer thickness is dictated by several factors including net rainfall recharge, size of the island and permeability of the soil column. Because these parameters vary from island to island, the quality of the aquifer also varies. The proximity of most aquifers to the island surfaces, however, makes them generally vulnerable to pollution and contamination from human activities as well as salt-water intrusion. For these reasons, the availability of groundwater as a freshwater resource has been limited. Thirty-nine inhabited islands have water suitable for drinking, 162 do not. On islands where groundwater is being used, it is tapped for communal wells that provide water mostly for cooking.

Groundwater supplies experienced a number of significant negative impacts from the tsunami. Groundwater was forced up and out of some wells, while others were inundated by floodwater, resulting in dramatically increased levels of salinity. Leaking septic tanks further contaminated the water (see Case study). A joint mission by UNICEF with the Maldives Water and Sanitation Authority found high levels of salinity and microbial contamination. Faecal coliform levels were found to be greater than 100/100 ml, substantially in excess of acceptable levels. The GOM estimates groundwater in 36 islands may have been compromised by sewage contamination from damaged septic tanks or floodwater. Remediation of groundwater supplies, which have been rendered unusable, will likely take several years. In the meantime, residents of affected islands would face risks from kidney damage and various diseases (cholera, typhus, diptheria and enteric fever) if they were to consume groundwater with high levels of salinity and faecal coliforms.

Coral Reefs

The Maldives are home to a vast system of world famous coral reefs that attracts tourists from around the world. The country's lagoons and reefs combined make up approximately 21,300 square kilometres. The reefs comprise approximately 200 coral species and provide habitat for an extraordinary array of fishes and marine life. In 1998, the country's reefs suffered from extensive bleaching that killed an estimated 90 per cent of the country's coral. Against that backdrop, any further damage to the coral reefs must be taken seriously.

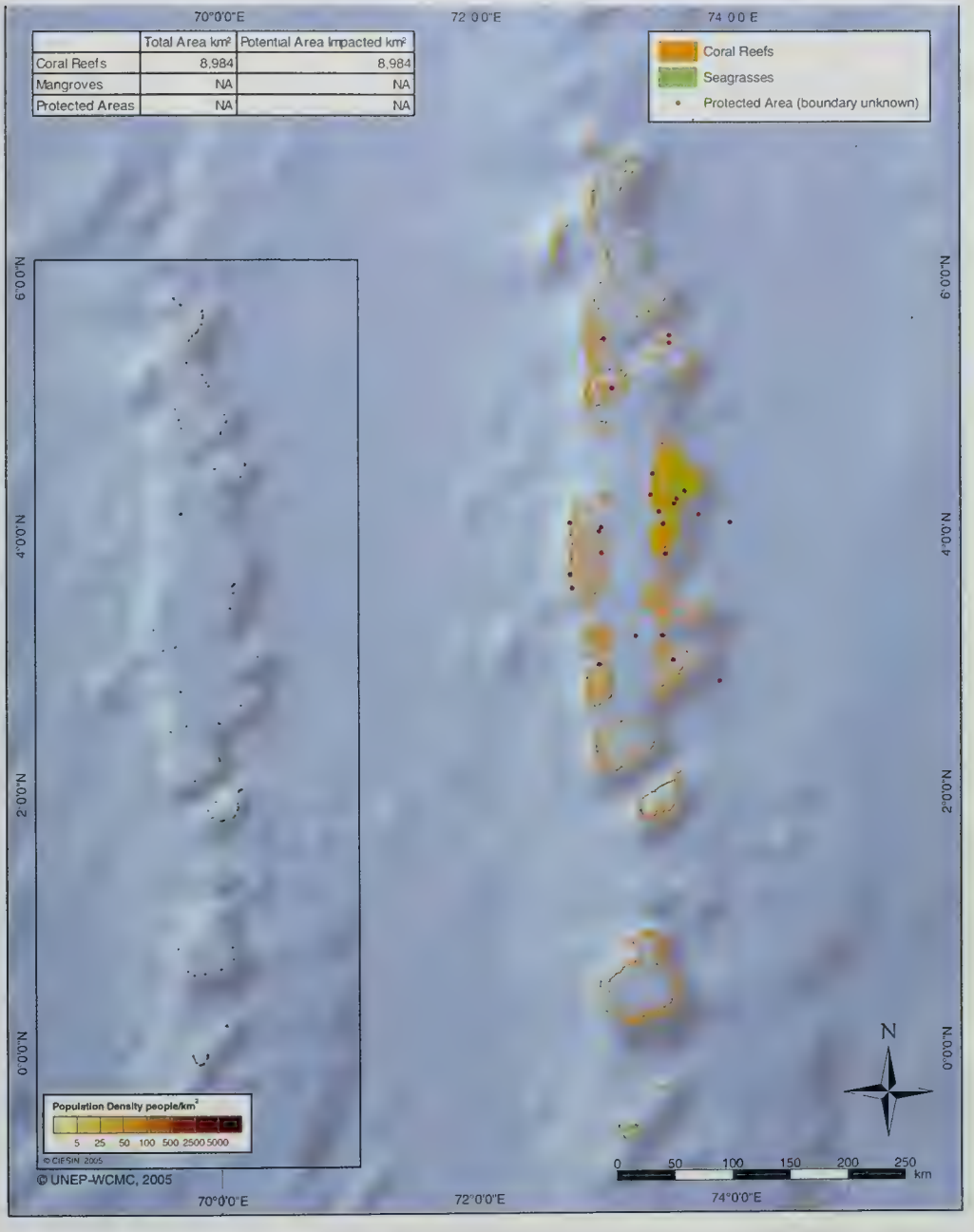
On 9 February 2005, an interdisciplinary team of experts sponsored by the Government of Australia (AusAID) completed a report to the GOM based on a survey of 177 kilometres of coral reefs at seven of the country's 26 atolls. The team reported that the tsunami generally had little direct effect on the country's coral reefs. The extent of the damage varied among and across atolls. Solid waste build up appeared to be minimal. The most serious concern was that sand and sediment was found to have coated and in some cases smothered sections of coral, particularly at lower depths. The sediment build up poses a threat by potentially making reef surfaces unsuitable for future growth or re-growth. In addition, solid waste was found to have washed up against some of the reefs.

Coastal Zone

Because island coastlines buffer the Maldives inhabitants and infrastructure, and are of crucial importance to the country's tourism, coastal erosion is a serious environmental concern. The country's beach systems are highly dynamic and subject to seasonal conditions, especially from monsoons.

The tsunami caused widespread damage to the coastal environment including coastal infrastructure. Initial reports estimated that over 10 million square metres of beach on 130 islands was eroded by the tsunami's force. Extensive erosion caused sediment to accrete in the harbours of 44 islands, impacting a total area of approximately 400,000 square metres. On some islands, large areas of coastal vegetation,

Priority Ecosystems and Protected Areas in the Maldives



website: www.unep-wcmc.org

please contact Kaveh Zahedi or Phillip Fox for further details

All data on Protected Areas, Coral Reefs, Seagrasses and Mangroves are available from UNEP-WCMC databases
Data on population density kindly provided by CIESIN

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which includes a local variety called *heylhi,* as well as sea lettuce, ironwood and screw pine, were either damaged or completely destroyed. Because coastal vegetation often plays a vital role in stabilizing beach sand, the loss of coastal vegetation may well increase coastal erosion.

Soil

The soils of the Maldives are shallow (0–20 cm) and generally rather coarse, containing substantial quantities of coral rock and sand. Island soils tend to be highly alkaline, rich in iron and deficient in nitrogen.

Initial indications are that the tsunami caused salt water to wash off soil on most of the impacted islands. The natural composition of the soil has probably been altered, which will impact local vegetation and agricultural productivity and home food gardening. In some reported cases, when groundwater escaped out of the wells, cavities were created and the ground collapsed.

Protected Areas

The Maldives has 25 officially designated marine protected areas (MPAs) and one area that encompasses both marine and terrestrial ecosystems (Hithadhoo Protected Area). These areas have significant biological, physical, aesthetic and recreational value. Although they have not been declared protected areas, two islands, Hithadhoo and Hurasdhoo, have been identified as ecologically significant. Hithadhoo has the largest frigate bird nesting site in the country, and Huradhoo is a uniquely formed island with endemic vegetation.

Very limited assessments have been undertaken to identify the environmental impacts of the tsunami on protected areas. An expert team sponsored by the Australian government recently visited two MPAs. The team reported that there was not significant physical damage to the MPAs visited. They did, however, find evidence of sedimentation at these sites. No physical damage was identified on the recently designated Hithadhoo Protected Area. It is possible, however, that salt water may have impacted the Eidhigali Kilhi area, which has the highest conservation value within that Protected Area. No field assessments have been carried out either in Hithadhoo or Hurasdhoo. The Hithadhoo Atoll Office reports that some of the vegetation that supports the frigate birds roosting Hithadhoo has been damaged.

Mangroves

There is very little documented information available on the mangroves of the Maldives. Mangrove habitats are not evenly distributed across the country. Southern atolls have more abundant and diverse mangrove areas than those in the north with the northern atolls of Shaviyani and Haa Dhaalu providing the exception. A 1991 study by Untawale and Jagtap identified 13 species of mangroves and six species of other plants and 37 species of fungi associated with mangrove habitats. A number of islands in the country have mangrove swamps ranging from very small thickets to large ponds. On many islands, the mangroves are 'closed' and are found in island depressions that typically contain large quantities of humus. Other islands have mangroves fringing brackish water regions.

Although no large-scale damage to mangroves in the Maldives was reported as a result of the tsunami, initial field investigations identified a number of impacts on some islands, including erosion of land around mangroves and damage to mangrove-associated vegetation. These impacts can have implications for birds and other fauna residing within mangrove habitats. The health of mangrove systems is also increasingly being recognized as a buffer against natural catastrophes.

Surface Water

Freshwater can be found in ponds on some Maldives islands. These ponds provide important habitats for island ecology, serving as water reserves for animals and plants.
Floodwaters from the tsunami have dramatically increased salinity in ponds on the impacted islands. Because the bottoms of these ponds are impermeable, recovery from the tsunami's impact will likely take many years.

5.4 Preliminary Findings: Impacts on the Human Environment

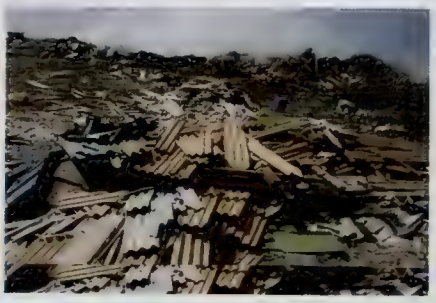
Solid Waste

Waste is one of the most environmentally challenging issues in the Maldives. There is little provision of waste management services on the islands. Householders are required to carry their waste to disposal sites. Less than 2 per cent of the islands have imposed a fee for a service system. All inhabited islands have designated disposal sites, but most are uncontrolled and waste is frequently being burned. There are three main landfill sites in the northern, central and southern area with limited disposal facilities. There is little segregation of waste, except at Thilafushi Island, which collects waste from Male and the neighbouring islands of Villingili and Hulhule. The country has no hazardous waste facilities. With an increase in economic activities, especially in the tourism sector, the need for waste management services has grown urgent in recent years.



Kolhufushi Island, Maldives (10 January 2005). Cassim Fahim, a tsunami survivor walks through the destruction on Kolhufushi Island. The tsunami had a substantial impact on the nation's economy, which depends largely on nature tourism, fishing and agriculture. © Anuruddha Lokuhapuarachchi/Reuters

Case study: Asbestos waste in the Maldives



Asbestos roof sheeting at a dump site on Thilafushi Island, Maldives, 14 January 2005.



UNEP investigations of tsunami-affected islands consistently found solid waste dispersed over entire islands. Tsunami-related debris contains a mixture of demolition waste, household waste from former dumpsites, vegetation, metals, animal remains and hazardous compounds. Of particular concern is the presence of asbestos from roof sheeting. Initial clean-up operations have frequently worsened conditions by piling debris on the beaches, where it either washes off or threatens groundwater. UNEP has worked with the Maldives MEC to provide disaster waste guidance and waste management workshops and to commence an emergency asbestos management programme.

UNEP estimates that the tsunami created approximately 290,000 cubic metres of demolition waste, which combines with approximately 50,000 cubic metres of pre-existing household and other waste. Much of this debris was dispersed over the affected islands. The waste is diverse in nature, comprising hazardous waste (including asbestos), vegetation, soil, sediment, municipal waste from dump sites, healthcare waste, human and animal remains and excreta, demolition waste (concrete, brick, timber, etc.) from destroyed buildings, oil spilled from generators, leakage from septic tanks and wastes generated by relief operations. Redistributed waste lying on the soil and beaches threatens to contaminate groundwater supplies and the marine environment. Clean-up efforts to date have either not improved conditions or, in some cases, have worsened them (see Case study). These conditions pose risks to human health from illness, infection, injury or inhalation of smoke. They are also impeding island services and access routes and may adversely impact recovery and reconstruction efforts.

Wastewater

Sanitation in most islands depends on pour-flush latrines and cistern-flush toilets connected to septic tanks and, to a lesser extent, holes in backyards. In high-density island environments, septic tanks are often poorly constructed and maintained due to the unavailability of material and skilled labour. Small-bore systems are a common alternative but they are generally not well designed, often malfunction and usually convey raw sewage directly into the lagoon. Assets deteriorate rapidly due to deferred maintenance, and faulty systems are polluting the marine environment. A large number of septic tanks are linked to soak pits, from which sewage can migrate freely through the highly porous island soil and contaminate groundwater supplies. The remaining septic tank systems are connected to sewerage systems with sea outfalls. Sewage treatment systems are scarce in the islands. Male is not served by a sewage treatment system.

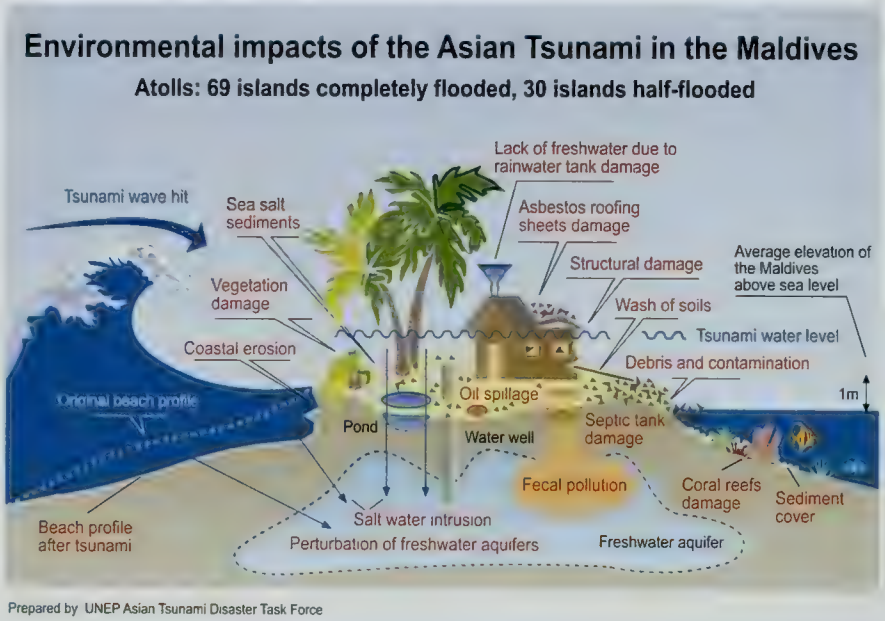
The extent of damage to the sanitation and sewerage network is still uncertain. The addition of displaced families from severely impacted islands has, in some cases, doubled host island populations, putting an enormous strain on local sanitation systems. Water and sanitation emergency requirements for the Maldives were identified to support approximately 2,200 affected households (equivalent to an estimated population of 15,000) in 69 islands. In extensively affected areas, where entire islands have been subjected to flooding for an extended period of time, septic tanks need to be replaced or, if undamaged, desludged. Up to 90 per cent of toilets may have been lost on very highly impacted islands, up to 75 per cent on highly impacted islands. The pilot aerobic sewage treatment plant on Kulhudhufushi, and the Maldives Water and Sanitation Authority (MWSA) pilot reed bed facilities have not reported any damage to their infrastructure.

Water Supply

Most islands in the Maldives collect water from communal rainwater storage tanks or from individual household tanks and, to a lesser extent, through groundwater extraction. Only four islands in the Maldives, comprising 28 per cent of the population, have desalinated water available.

According to present assessments, drinking and cooking water harvested in household and communal water tanks were totally lost in the 69 most affected islands (see Table 1). According to the MWSA, 96 per cent of rainwater storage tanks were damaged along with catchment areas. No significant impacts have been reported on the water distribution in Male or Villingili. On one of the most severely affected islands the desalination plant stopped production of water. The loss of freshwater has come during the dry season in the Maldives, when there is little rain to help recharge freshwater supplies, making the complete impacts of this loss difficult to identify at present.

Case study: Groundwater contamination in the Maldives



Prepared by UNEP Asian Tsunami Disaster Task Force

The tsunami caused extensive groundwater contamination in 69 affected islands in the Maldives. Seawater with high conductivity infiltrated the islands' shallow aquifers and combined with sewage from destroyed septic tanks and sewer systems. Sea outfalls close to shorelines were damaged, causing further leakage into the aquifers. Investigations found waste and hazardous substances, such as spilled oil, near groundwater wells, most of which are unprotected and vulnerable to contamination. Initial sampling found bacteriological contamination in all groundwater samples.

Table 1. World Bank/ADB Preliminary damage assessment

Damage Indicator	Estimated Damage
Community rainwater tank	Up to 1,000
Household rainwater tanks	Up to 6,000
Rainwater supplies	20,000 m^3
Roof harvesting piping and gutter systems	5,000 households

Table 2: Number of islands and type of damage caused by the tsunami

The Government has divided islands damaged by the tsunami into four categories based on the degree of impact.

Island category	No. of islands	Characteristics
1	13	More than half of the population has been displaced by complete flooding and large structural damage. The entire population of these islands requires support.
2	82	Completely or half flooded, even if no structural damage has occurred. Flooding is likely to have destroyed or damaged agricultural lands, seeds, tools and fertilizers or equipment needed for specialized income activities such as power tools for carpenters. Islands with lower levels of flooding that have suffered structural damage have implied asset losses and have been placed in this category
3	23	Between a third and a half of the island has been flooded even if no structural damage has occurred
4	81	Islands that have minimal flooding and require monitoring to determine whether agricultural production has been affected

Tourism Sector

Tourism is the country's largest industry, accounting for 31 per cent of gross domestic product (GDP) with total receipts estimated at $ 415 million in 2004. Pre-tsunami scenario indicators reveal that the hotel sector had provided 17,000 jobs for the country's economically active population of 88,000. Adding in tourism-related industries, tourism has been responsible for over 25,000 jobs. Tourism in the Maldives is nature based. The terrestrial and the marine environment – the beauty of the underwater world at the reefs, clean water in the lagoons and the pristine sandy beaches – are the major features attracting tourists to the Maldives. Over 20 per cent of the country's approximately 600,000 annual visitors are divers who come to see reefs, dive spots and marine protected areas.

The tsunami had disastrous effects on the tourism sector. Three foreign tourists died, and 19 of the country's 87 resorts sustained damages and are closed. Rebuilding the resorts will cost an estimated $100 million. Business losses are estimated at $250 million. Tourist arrivals have declined markedly. Typically, in January and February, high season, bed occupancies are at 90 per cent. The bed occupancy rate, however, has declined by between 20 and 30 per cent, and approximately 5,000 of the country's 17,000 hotel beds are not in use. Of that number, 1,200 hotel beds have sustained serious damage and will remain closed for 2005. Scheduled and charter flights have been reduced and many resorts have reduced their staff sizes. In the interest of regaining previous tourist arrival rates and restoring damaged resort capacities, the Ministry of Tourism has been providing situation updates to travel and trade partners and diplomatic missions. The Ministry has also formulated a post-tsunami marketing campaign, relaxed resort leases rents for a 3-month period and provided technical assistance to the tourism industry regarding insurance claims.



Guraidoo Island, Maldives (16 January 2005). Fisherman clean their catch on the beach on Guraidoo Island in the Maldives. Maldivians who lost their homes have started rebuilding their villages and have gone back to fishing. The Government of the Maldives estimates that infrastructure damage to the fisheries sector is valued at $25 million. © Ed Wray/Associated Press

Fisheries Sector

In 2004, the fisheries sector contributed 9.3 per cent of the country's GDP. The sector is is a key component of rural livelihoods and income, and is commercially very significant, consisting of subsistence-based pole and line fisheries as well as commercial fisheries and small processing units. The GOM estimates that infrastructure damage to the fisheries sector is valued at $25 million. Damages includes the loss or destruction of 120 fishing vessels, partial damage to 50 vessels and several boat sheds as well as losses of reef fishing boat equipment and ocean cages. In addition, 374 fish processors lost equipment and two fishery institutes were damaged.

Agriculture Sector

In recent years, agriculture has become commercially significant, with increases in both private and public sector investments. The demand for fresh agricultural products has paralleled increases in the country's tourism base. In 2003, agricultural production was estimated at 35,821 tons, 2.6 per cent of GDP. Coconut is the most widely harvested product, but production of cucumbers and melons has also increased significantly in recent years. For commercial farming purposes 32 uninhabited islands are rented for 21-year periods, and 941 uninhabited islands are leased out through the country's traditional leasing system for development activities that include agriculture. In addition, 75 per cent of inhabited islands are utilized for some degree of agricultural activity. Cash-based employment has been initiated in most islands by the government, the private sector and national and international NGOs.

The agriculture sector was one of the worst hit by the tsunami. The Government estimates that seawater damaged field crops on 1,271 farms, backyard crops and fruit trees on 9,016 homesteads and over 840,000 timber trees in inhabited islands. The direct damage from saline intrusion to agricultural land and groundwater resources is severe. Groundwater is used as the only source of irrigation in the agricultural sector. The GOM estimates that six to nine months will be required to get vegetable production back on track and over five years to restore agriculture to pre-tsunami levels. The Ministry of Fisheries, Agriculture and Marine Resources has calculated that $11.1 million will be needed to restore the sector. As of January 2005, the Government was distributing food to an estimated 36,000 people who are displaced and have lost their homes, tools and equipment or that have suffered damage to their homes.

Airports

The airport sector consists of one international airport, in Male, three southern regional airports, one in the northern atolls and a number of private airstrips. Fortunately, the airports were located on islands where the impacts of the tsunami were minimal.

Maritime Infrastructure

In addition to the main port in Male, the country's 199 inhabited islands are serviced by 90 man-made harbours, quays, basins and breakwaters; several natural harbours and jetties; and approach channels to access inner atolls. The maritime transport sector also includes inter-island shipping routes marked by 19-kilometre light beacons and 3-kilometre reef markers and harbour entrance markers.

The tsunami damaged or destroyed 36 jetties (totalling 1,600 metres in length), 4,200 metres of quay wall and 15,000 metres of harbour sea walls. In addition, 375,000 cubic metres of basin dredging and 145,000 cubic metres of entrance dredging were damaged. The tsunami also destroyed twenty-five 19-kilometre light beacons, sixty-five 2-mile reef markers, 120 (of 390) entrance markers and approximately 300 metres of causeway. In general, maritime facilities located on the inner sides of the atolls experienced less damage from the tsunami than did other maritime infrastructure.

Energy

The Maldives has no conventional energy resources (e.g., oil and gas) that it can utilize to meet its energy needs. The country instead relies on imported petroleum fuels to meet all of its energy needs, including power generation, transportation, lighting and food preparation. Damage to the energy sector includes failure of island power systems due to damaged diesel generators and damage to electricity distribution networks and street lights. According to the Ministry of Communications, Science and Technology (MCST), the damages to power plants operated by the State Electric Company have been assessed at $4.6 million. In addition, the loss to the energy systems for the public and private sector on the 199 inhabited islands is estimated at $5 million. This includes damage to power generation and

distribution equipment, and imported fossil fuel lost during the disaster. An assessment of the damage to the energy sector in the resort islands, some industrial islands and airports, where the electricity is generated by their own power plants, has not yet been conducted by MCST.

5.5 Preliminary Findings: Environmental Management Capacity

More so than many countries, the economy of the Maldives depends strongly on protection of its highly prized natural resources. Meeting this challenge requires strong technical and scientific expertise and inputs into the preparation of policies and standards. At present, the MEC Environment Section and the Environmental Research Centre are largely understaffed for the broad and sometimes unclear mandates given them. In the face of urgent needs to implement programmes and projects to address priority environmental concerns, such as those outlined above, the Ministry's two environmental units have been limited to coordinating and monitoring activities and desk-bound reviews of government activities and the broad range of issues within the MEC's mandate. Environmental capacities at the atoll and island level are virtually non-existent.

Environmental Framework Laws

In 1993, the People's Majlis adopted the Environment Protection and Preservation Act. The Act established a framework upon which regulations and policies can be developed to protect and preserve the country's environment and natural resources. The Act was passed to support and promote the protection, enhancement and prudent use of the environment while recognising such principles of sustainable development as the precautionary principle, pollution prevention, waste reduction and polluter pays. The Act also acknowledges the crucial link between environmental protection and economic progress. The Maldives has been a party to a number of multilateral environmental agreements and was the first country to sign the Kyoto Protocol. In general, however, the country's environmental legislation is underdeveloped, with regulations needed for most sectors. In addition, the MEC has no environmental inspection and enforcement capacity.

Environmental Impact Assessment

Like many small island developing states, the Maldives has urgent needs and objectives, some of which are mutually conflicting due to the scarcity of available resources. The Environmental Protection and Preservation Act requires that EIAs be performed for all development projects. Although the EIA process is still relatively new in the Maldives, it has been instrumental in streamlining development activities in some sectors. Since 2001, 76 development projects were asked to undertake EIA for its approval. Fifty-four projects were from the tourism sector and five were from the fisheries sector. EIA work, however, has not yet been properly integrated into public sector development projects. Since 2001, 74 coastal modification projects have been undertaken in the inhabited islands without any formal environmental review.

The GOM has developed a Focus Island Concept and Population Consolidation Strategy that aims to identify structurally sound islands where infrastructure can be built and to which populations from smaller, less inhabited islands can be relocated. Taken together with the extensive post-tsunami reconstruction anticipated, a great deal of development appears to be on the horizon. Effective environmental planning and impact assessment will be of paramount importance.

Coastal Zone Management

The coast is an important element of life for all Maldives citizens. Although the coastal zone provides a range of recreational, economic, conservation and heritage values, coastal zone management is not properly defined. Responsibility for coastal zone management is spread over several ministries – the

Ministry of Atolls Development, Ministry of Fisheries Agriculture and Marine Resources, Ministry of Planning and National Development, Ministry of Tourism, Ministry of Transport and Civil Aviation and Ministry of Environment and Construction. This dispersion of responsibility has hindered the formulation of an integrated and sustainable coastal zone management plan. In the absence of a comprehensive coastal management plan, attention has been focused on beach erosion. According to the *Maldives State of the Environment (2004)* coastal erosion was reported in 109 islands and is visible in most islands. The coastal infrastructure of most islands is vulnerable due to the vegetation line's close proximity to the sea.

Early Warning

The Department of Meteorology keeps constant watch for weather-related disasters and issues warnings in the event of tropical disturbances, torrential rain or strong winds. The Department also monitors seismological activities and physical oceanography. Although seismometers are vital to maintaining continuous records of earthquakes, the high cost of seismic monitoring systems has prevented the Maldives from obtaining one. Subsequent to the 26 December tsunami, the Department has been continuously monitoring seismic activity reports from various seismic centres around the world and feeding relevant information to the GOM Disaster Management Centre. A tsunami warning system is in place across the Pacific Ocean, but not in the Indian Ocean. Tsunamis are rarer in the Indian Ocean, where seismic activity is much less frequent than in the Pacific. There have, however, been seven recorded tsunamis triggered by earthquakes near Indonesia, Pakistan and the Bay of Bengal. The implementation of a proposed Indian Ocean Tsunami Warning system would take an estimated two to three years. During that period, the Maldives will remain highly vulnerable to natural disturbances.

Disaster Management

The major disaster risks facing the Maldives are related to climate change factors, storm surge and tsunamis. While tsunamis are extremely destructive, as demonstrated by the current tsunami disaster, they are also unusual events (the country has not been significantly affected by cyclones, which often hit other areas of the Indian Ocean). As a consequence, the country has focused on what it has seen as its main risk – global warming and consequent rising sea-levels. Despite the moderate hazard risks, the vulnerability of the country is quite high due to its special geophysical characteristics – i.e., small and low-lying islands.

Male, Maldives (14 January 2005). People gather driftwood from a breakwater in Male, the capital of the Maldives. The tsunami which killed over 150,000 people left the people of the Maldives worried about the already fragile ecosystem of this string of thousands of atolls. It also caused water shortages for people living on the remoter islands. © Ed Wray/Associated Press



The country's mandate for disaster management was originally given to the Committee on Natural Disasters. The Committee was subsequently merged into the National Commission for Protection of the Environment (NCPE) in recognition of the linkage between possible disaster risks and environmental factors such as storm surges, high winds and sea level rise. Following the tsunami, a Ministerial Committee and Technical Task Force was established and later transformed into the National Disaster Management Centre. The Centre has facilitated response and coordination activities. The GOM's Focus Island concept and Population Consolidation Strategy, if implemented, would also have important implications for disaster management planning.

5.6 Conclusions and Recommendations

Strengthening Environmental Capacities

The country's environmental protection capacities need to be expanded and strengthened on an urgent basis. With a national economy based principally on nature tourism, the risks of deferring action to prevent and mitigate pollution and resource depletion are too great for the country to assume. The MEC needs additional technical and administrative staff as well as training and other assistance aimed at strengthening management and technical skills. Consideration should be given to separating the environment and construction functions of the MEC to create a separate environment ministry, as should development of atoll-level environmental capacities.

Rehabilitation of Natural Resources

Detailed assessments of the environmental and economic losses caused by damage to the marine and terrestrial natural resources of the Maldives are urgently required. An estimate is needed of the costs of restoration of important habitats and biodiversity. Priority rehabilitation projects need to be identified and supported. Immediate management and recovery plans are required for short and long-term management of the country's protected areas.

Environmental Planning

As recovery and reconstruction efforts progress it is essential that environmental review and planning be conducted in advance of development in order to properly site new infrastructure, prevent pollution, reduce environmental risks, establish appropriate environmental management systems and avoid future clean-up costs. Building codes should be strengthened to ensure structural integrity of planned structures. This process should be spearheaded by the MEC, which will require additional support and training, working in close cooperation with the Ministry of Planning and National Development.

Waste Management

Disaster waste needs immediate attention. Disaster waste management activities should include proper training and capacity building for clean-up crews and controlled clean up campaigns, hazardous and health care waste collection and storage, identification of appropriate sites, and reorganization of waste handling and transportation. Activities should be focused on the development and implementation of short-term, community-based strategies that will swiftly reduce environmental and public health risks while, at the same time, building towards long-term integrated waste management. Further legal, institutional, technical and financial support is urgently needed to ensure the long-term sustainability of waste management services. Similarly, capacity building within relevant ministries and agencies is required in order to develop and implement an effective and sustainable waste management system.

Surface, Groundwater and Soil Rehabilitation

Detailed assessments of groundwater impacts are urgently required as are immediate interventions aimed at reducing pollution and public health risks caused by contamination of water supplies. Surface water quality should be surveyed to determine ecological impacts, probable rates of recovery and needed conservation and management actions. Soil surveys are needed on a representative sampling of impacted islands in order to prepare recovery plans for soil and vegetation.

Water Distribution

Short-term recovery needs should focus on the immediate provision of safe drinking water to affected islands, dovetailing with the water and sanitation work already begun by international agencies. Available data indicates that a significant number of additional household and communal rainwater tanks is urgently needed. The impacts of salt water intrusion and contamination by sewage of groundwater needs to be assessed in detail in order to avoid improper use and to enable the development and implementation of strategies to provide alternative supplies, as needed, and to protect and restore groundwater quality.

Wastewater

Rehabilitation and replacement of damaged infrastructure (toilets and septic tanks) is urgently needed in households and communal buildings on the islands most impacted by the tsunami. The GOM is seeking assistance for construction of permanent septic and hygienic sludge drying beds; repair or replacement of damaged or undersized small bore sewers and sea outfalls, where damaged; the introduction of sewerage network systems in islands that are relying solely on septic tanks/soak pit systems; and the introduction of cost-effective sewage treatment facilities. Further testing and piloting of reed bed systems should be further explored. To ensure the long-term sustainability of these facilities, capacity building within relevant authorities will be needed.

Coral Reefs

The Maldives coral reef monitoring programme needs to be expanded to cover more reefs and to enable a detailed assessment of the tsunami's impact on fragile, already-depleted coral populations and related ecosystems. Expansion of the country's marine protected area network is crucially important in order to protect the Maldives invaluable coral systems. The capacity of the Ministry of Fisheries, Agriculture and Marine Resources to monitor, analyse and protect the Maldives marine resources should be expanded and strengthened.

Livelihoods Recovery

The re-establishment of the agricultural sector will require restoration and improvement of soil and water resources, forests, crop rehabilitation, technical assistance and strengthening of institutional capacities. The GOM's goal is to rehabilitate the fisheries industry in two phases. The short term phase (6 months/June 2005) will include immediate repair work. The mid-term goal (2.5 years/December 2007) includes replacement of damaged fishing vessels and fishing gear. The GOM also envisions a two-phase programme for restoration of maritime infrastructure.

Tourism Recovery

The Ministry of Tourism has identified short and long-term needs. Short-term requirements include reconstruction of damaged tourist facilities, implementation of a marketing campaign, training for new recruits required by the industry and retraining of unemployed staff. Long-term plans and requirements include strengthening disaster/crisis management planning, training, protocols and procedures, developing post-tsunami destination marketing, an assessment of the tourism sector economic loss, an assessment of the long-term impacts on marine life, and training and advice for hotel owners on insurance matters. Technical and financial assistance is required to undertake these actions. During the reconstruction process, the tourism industry should be encouraged to consider environmental protection and conservation needs and to adopt best environmental management practices.

Integrated Coastal Zone Management

A comprehensive assessment of the tsunami impact on the coastal zone is needed. Such an assessment would provide an important predicate to the development of a much needed integrated coastal zone management planning process. A study of the hydrodynamics around reef-top islands would provide valuable information for the design of coastal engineering and disaster management structures. Capacity building in the field of coastal engineering is also needed, as are studies of erosion management techniques and the development of technical guidelines for shore protection methods and procedures. These studies and guidelines could be prepared by a proposed Coastal Zone Engineering Unit that would operate in the MEC.

Early Warning System

A regional tsunami warning system needs to be established in the Indian Ocean. The establishment of an Indian Ocean Tsunami Warning system will take an estimated two to three years. During this transition period, a National Tsunami Warning System linked with a national tropical cyclone and storm surge (high wave) alert is needed within the Department of Meteorology. This system could be linked to the warning systems of neighbouring countries, particularly India and Sri Lanka.

Strong links must be developed between efforts to adapt to climate change and strategies to reduce risks from natural hazards. Many hazards experienced by the Maldives are related to the sea. The projected sea level rise may result in enhanced severity of some hazards and their impacts. Efforts focused on natural hazard mitigation alone might not prove effective in the absence of linkages with climate change impact reduction.

The Department of Meteorology's capacity should be enhanced, in particular in the fields of seismology and oceanography. The Department's working relationships with other counterpart agencies and regional and national organizations should be strengthened. The participation of Meteorology Department officials in regional planning and consultation meetings would facilitate the strengthening of an early warning system. A regional EWS meeting in Male would help network GOM agencies with international counterpart agencies.

A vulnerability assessment of the Maldives is needed from various aspects. A community based assessment through island-level task forces would strengthen preparedness planning. A national process would help assess mitigation options and identify new assets/infrastructure. The vulnerability assessment process should be linked with vulnerability assessments of ecosystems and natural resources that are serving as natural protection. The vulnerability of the country's coral reefs could be assessed with specific reference to the long-term implications of coral bleaching that occurred in 1998.

Multi-hazard preparedness planning is recommended for the atolls. Preparedness plans would equip people government officials and community members to know their roles before, during and after disasters. A feasibility study on the establishment of a multi-hazard early warning system is recommended. The feasibility study would provide an outline of the system including institutional and technical details, capacity building and training needs, awareness programmes, phased work plans, and proposed financing arrangements for the establishment and operation of an integrated national early warning system on a sustainable and continuous basis. The national system could be built on the existing observatories of Atmospheric Brown Clouds (ABC) and the Male Declaration on Control and Prevention of air pollution and its Transboundary Effects for South Asia.

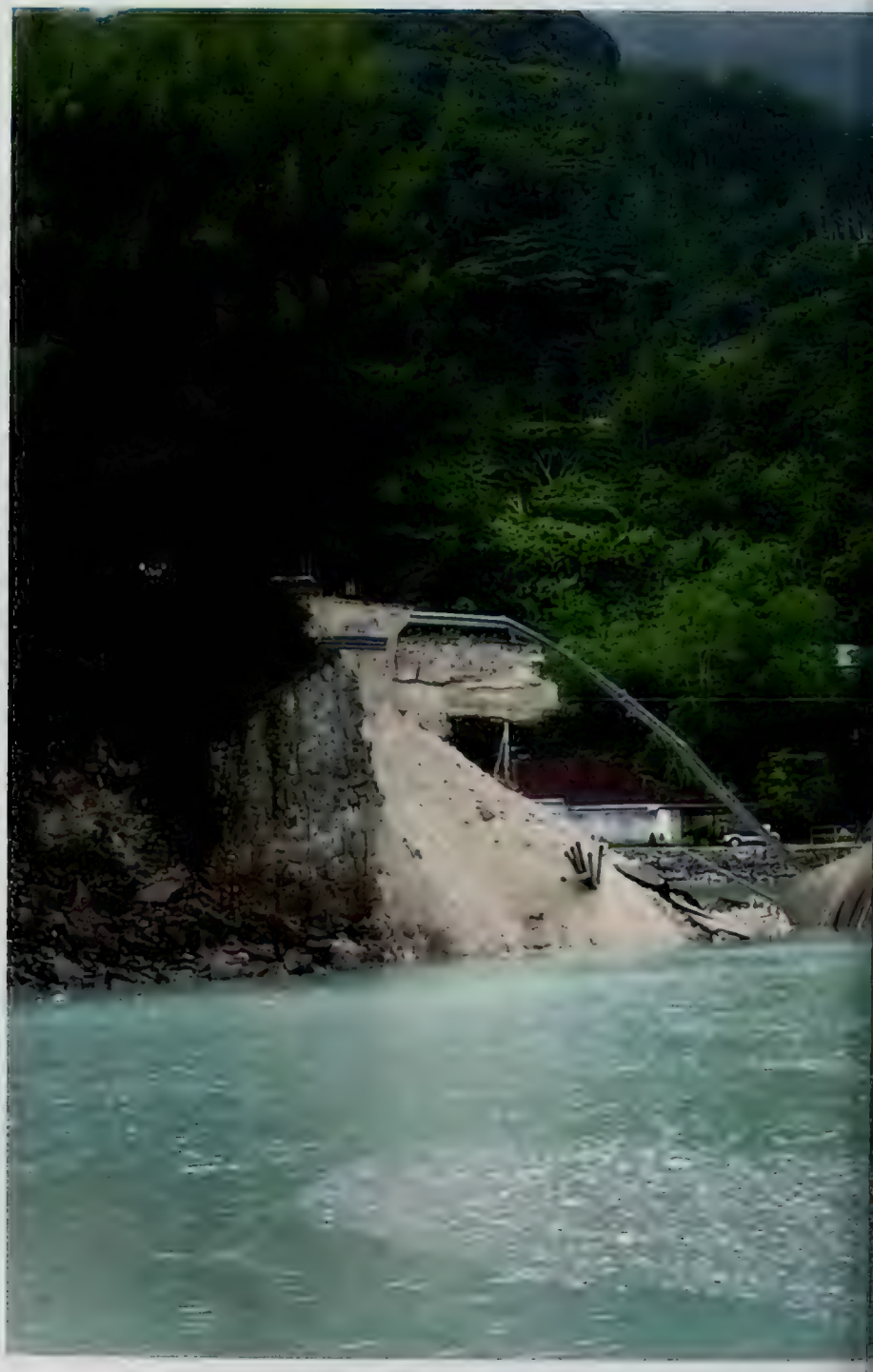
Disaster Management

The GOM should initiate an effort to develop a national policy for disaster management. The disaster management roles and responsibilities of various ministries should be clearly delineated. A national disaster management authority could function as lead agency for disaster management. Legal instruments for enforcing land use planning and building codes are needed. Energy saving and other green design should be taken into full account in the development of such legislation. Community emergency protection plans should be developed with guidance from relevant state authorities. Emergency shelters should be established on high ground. Technical and environmental guidance will be needed for appropriate shelter designs. Disaster management efforts are closely interwoven with sustainable development goals. Development processes aimed at social and economic improvement could generate significant new disaster risks. Major development programmes and projects need to be reviewed for vulnerability and hazard and their potential impacts on the environment.

References

This report was compiled using data supplied by the Ministry of Environment and Construction, Ministry of Tourism, Ministry of Fisheries, Agriculture and Marine Resources, Ministry of Planning and National Development, National Disaster Management Management Center, Ministry of Communication, Science & Technology, Maldives Water and Sanitation Authority, Environment Research Center, Marine Research Center and the Department of Meteorology. The 2004 State of the Environment Report (Ministry of Environment and Construction 2004) was an invaluable source of additional information about the Maldives environment.

SEYCHELLES



Seychelles (28 December 2004). This bridge linking the Seychelles international airport with the capital, Victoria was destroyed by the tsunami. The sea water surges flooded low lying areas of Mahé, Praslin and La Digue, and caused widespread damage to beaches, coastal vegetation, roads, bridges, houses and other infrastructure.
© George Thande/Reuters



6. NATIONAL RAPID ENVIRONMENTAL ASSESSMENT - SEYCHELLES

6.1 Introduction

The tsunami that hit the Seychelles on 26 December had travelled about 5,000 kilometres from the earthquake zone from offshore Sumatra in less than seven hours. By midday an extreme low tide occurred throughout the granitic islands. At 1 p.m. waves ranging from 2.5 to 4 metres in height hit the east coast of Praslin and Mahé islands. The effects were felt all along the east coast of Mahé over a 30-minute period. Refracted waves hit the west coast of Praslin and Mahé between 30 minutes and one hour after the respective east coasts were hit. Another wave occurred at 5 p.m., followed by two smaller waves at 10 p.m. and at 5 a.m. on 27 December. The second wave had more or less the same effect as the first because, although smaller, it occurred at high tide. The two smaller waves caused damage only on the west coast of Praslin.

The sea water surges caused by the waves flooded the low lying areas of Mahé, Praslin and La Digue and caused widespread damage to beaches, coastal vegetation, roads, bridges, other infrastructure and houses. The flooding lasted for about six hours. Two people lost their lives.

The tsunami was followed on 27 December by extreme weather, with rainfall reaching 250 millimetres in the northern and central areas of Mahé. Torrential rains continued for several days. Runoff from the hills formed virtual rivers that swept across the country, causing widespread landslides and tree and rock falls in the northern and central part of Mahé and in other areas, with associated further damage to infrastructure, dwellings and vegetation on slopes.

Rapid assessments of impacts from the tsunami were conducted by the Government of the Seychelles (GOS). Efforts were hampered due to the heavy rainfall immediately following the tsunami, and by the limited number of staff in agencies with responsibilities in multiple areas.



Mahé Island, Seychelles (27 December 2004). President James Michel of the Seychelles inspects damage to infrastructure in the Seychelles. Initial assessments of damage to roads, fishing infrastructure, agriculture, public utilities, schools, land, houses, sports facilities and tourism establishments indicated damage amounting to $30 million. © George Thande/Reuters

Despite these challenges, initial assessments of economic damage were made rapidly incorporating damage to roads, fishing infrastructure, agriculture, public utilities, schools, reclamation land, houses, sports facilities and tourism establishments. Total estimates of damage amounted to SR 165 million ($30 million).

6.2 Overview of the Environmental Response

A few days after the tsunami hit the shores of the Seychelles, a preliminary estimate of damage to the environment was provided by the Department of Environment of the Ministry of Environment and Natural Resources. This preliminary assessment of environmental impacts covering damage to shorelines, vegetation, 'environmental infrastructure' such as pavement walkways and municipal parks, amounted to a total restoration estimate of SR 7.25 million ($1.3 million). However, this figure is now considered too low.

On 21 January 2005, following a meeting at the Mauritius meeting of Small Island Developing States, UNEP Executive Director Klaus Toepfer received a request from President Michel of the Republic of Seychelles for technical and financial assistance in conducting a rapid assessment of the environmental impacts of the tsunami. This assessment was to focus on understanding the long-term consequences of the tsunami on marine and coastal ecosystems, and to assess the stability of the coastline. In addition, the work was to address rehabilitation needs of services for the Marine Parks Authority and study current levels of disaster preparedness and early warning capacities.

Requests for support were also received from the Seychelles Ministry of Foreign Affairs as well as from the National Disaster Secretariat.

As the first stage in responding to this request, UNEP organized a fact-finding mission to the Seychelles during the period 3–10 February 2005. The mission involved UNEP experts on environmental assessment and disaster management, as well as IUCN experts on coral reefs, and experts on coastal zone management. Based on the findings of the fact-finding mission, a more detailed technical assessment is planned for March 2005 to collect additional information as well as detailed impact and risk analyses.

Key stakeholders in the Seychelles natural resources sector are spread across governmental, non-governmental and private sectors. In addition to the great interest shown by the President's Office, the Ministry of Environment and Natural Resources shoulders key responsibilities. These include forestry, crop development, national parks, conservation of biodiversity, pollution control and waste management, environmental impact assessment (EIA), coastal management and hydrology, meteorology, and botanical gardens.

Fisheries are managed by a parastatal corporation, the Seychelles Fishing Authority. Of great importance for assessing the impacts of the tsunami is the Seychelles Centre for Marine Research and Technology-Marine Parks Authority (SCMRT-MPA), a parastatal responsible for many aspects of research and conservation in the coastal zone.

The Public Utilities Corporation is responsible for assessing impacts to freshwater and sewage systems, while the Seychelles Fishing Authority is addressing impacts to the Fisheries sector. Agriculture and soil impacts, are covered by Crop Development and Promotion and Landscape Management.

The non-governmental sector includes several organisations such as the Marine Conservation Society of the Seychelles, Nature Seychelles, and the Seychelles Island Foundation.

To complete a rapid assessment, the team split into two groups for the purpose of field visits, two members concentrating on underwater work, while the remaining four were land-based. Coral reefs and marine habitats were assessed through existing documents and reef status assessments housed at SCMRT-MPA, together with a preliminary reef survey conducted by SCMRT staff assisted by IUCN in January-February 2005.

In geographical coverage, the main gap in the team's work was the focus on the inner granitic islands of Mahé, Praslin and Curieuse, to the exclusion of the coralline islands. Despite an overall impression that the tsunami has had only short-term impacts on the outer islands, there is clearly a greater hazard to such places from climate change, increased cyclones and sea-level rise. Many such islands, for example Aldabra, are of global significance in terms of biodiversity.

6.3 Preliminary Findings: Impacts on the Natural Environment

The Republic of the Seychelles comprises a group of 115 islands located in the western Indian Ocean between 4 and 11 degrees south of the Equator. The land area covers 455 square kilometres. A total of 41 islands are granitic, with rugged topography rising to a maximum altitude of 905 metres, including the so-called inner islands, of which Mahé (155 square kilometres), Praslin (38 square kilometres) and La Digue (10 square kilometres) are the most socio-economically advanced. All the granitic islands are situated within a distance of 50 kilometres from Mahé. The rest of the islands are coralline, rising only a few metres above sea level, and scattered throughout the western Indian Ocean. More than 95 per cent of the population of the 85,000 inhabitants is concentrated on the inner islands of Mahé (86 per cent), Praslin (8 per cent) and La Digue (2 per cent). The population density on the three islands is 468 inhabitants per square kilometre.

The Seychelles islands form part of the Indian Ocean Biodiversity Hot Spot and Centre of Plant Diversity. The biodiversity of the islands is therefore highly significant particularly in terms of plants, invertebrates, amphibians, reptiles and freshwater fish. Seychelles forests and biodiversity are under great pressure from various development sectors. The pressure is highest on the coastal plain which represents over 80 per cent of flat land or land of high value for development. This pressure is greatest on the coastal ecosystems such as lowland woodland, dunes, beaches and lowland wetlands including mangroves. The coastal plains of the three main populated islands of Mahé, Praslin and La Digue are predominantly covered by coconut plantations, trees of agro-forestry value and native coastal vegetation.

Coral Reefs, Sea Grass Beds and Sandbars

The Seychelles has a coral reef area of 1,690 square kilometres with 310 coral species and eight sea grass species. The islands form a critical stepping-stone in the biogeographic distribution of shallow marine species across the Indian Ocean.

Preliminary assessments in five islands suggest that little direct damage was caused by the tsunami on coral reef habitats and that the majority of assessed reefs experienced less than 5 per cent damage. However, damage was low partly because of the extensive reef degradation from the 1998 El Niño, estimated at 80-90 per cent, and only partial recovery since then. Many of the previously degraded reefs were particularly vulnerable to physical damage by the tsunami waves due to the weakened reef infrastructure and bio-erosion, but the general degree of prior degradation made assessment of the cause of damage unclear. Damage to the substrate was noted by the presence of scars where rocks and corals were torn off, and in back reef areas by exposed rubble that was previously covered by sand. Damage to corals was noted by broken branches of staghorn *Acropora* and branching *Pocillopora* colonies, and by damaged soft corals. In only a few cases, however, the extent of damage was between 5 per cent and 10 per cent, with a maximum of 27 per cent at one site in the marine park at St. Anne. High damage at this site was likely due to the rubble framework degraded by the El Niño coral mortality.

Damage to sea grass beds was similarly low, with only one definite case of damage recorded at Baie Ternaie Marine Park, Mahé Island. In this case, a sea grass bed adjacent to a drainage channel in the reef was smothered by sediment, probably mobilized from the extensive shallows and reef flat area, and backwash from land. Deposition occurred as sediment was being transported offshore by strong currents.

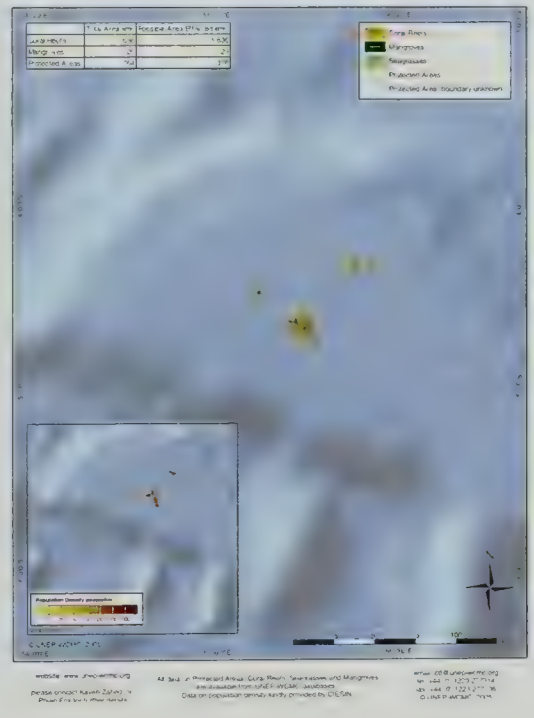
Beaches and Shorelines

There are two primary classes of natural coastline in the Seychelles: steep granitic shorelines, which are highly resilient to waves, and flatter coastal plains fringed by coral reefs, which are more vulnerable. A third class of shoreline, those protected by coastal reclamation, is artificial and increasingly important around Victoria. These basic shoreline differences had a profound effect on the impacts of the tsunami on the shoreline and terrestrial habitats: there were virtually no impacts on granitic coastlines (where the slopes exposed to ocean waves have prevented development on the shoreline itself), while coralline and highly altered shorelines around Victoria experienced significant damage.

Coastal erosion is considered a major problem and threat to human infrastructure along the coast. Chronic coastal erosion from wave impacts of tropical depressions/cyclones, has been identified at 25 major erosion hotspots. In some cases, such as Mahé and Praslin, erosion-sensitive sites are retreating an average of between one and three metres per year. Coastal sand and coral mining in the Seychelles over the past two decades has exacerbated the problem. However, these practices are now much reduced due to the enforcement of the Removal of Sand and Gravel Act (1991) and the Environment Protection Act (1994).

The effects of the tsunami on coastal erosion are clearly visible at both the exposed eastern side of the islands, but also at the western side like the Anse Kerlan beach section in the north-west of Praslin. The refracting tsunami waves caused erosion of beach cliffs of more than 2.5 metres in places. The rehabilitation costs of this single, eroding beach range between $0.5 million to $1.4 million depending on the type of protection option. It is believed that all erosion hotspots were impacted by the tsunami.

Priority Ecosystems and Protected Areas in the Seychelles



Mangroves and Coastal Vegetation

At present mangroves are limited to small patches within the coastal zone, covering a total of approximately 29 square kilometres. Nine mangrove species are recorded for the Seychelles. The marine national park of Port Launay on Mahé Island and the Curieuse Marine National Park, are the best protected areas. Behind the new land reclamation in front of Victoria, Mahé a new mangrove forest has developed. Beach crest and coastal vegetation is found bordering practically all-soft shores of the Seychelles. Much of it has been planted artificially and is a mix of local and non-local species.

The tsunami caused widespread impacts to mangroves and coastal vegetation. Direct impacts to the mangroves are caused by inputs of sand and silt that cover the pneumatophores (breathing roots). Furthermore, in some places the water circulation through mangroves will have changed due to direct effects such as newly created flow channels and indirect effects of blocked or altered circulation elsewhere. Significant short-term effects were not observed. Longer term monitoring of mangrove health could provide a clearer picture. Of major concern is the altered hydrodynamic environment in the Curieuse Marine Park. In this location, intensified circulation and wave exposure, caused by damage to the causeway, may threaten the future of the mangroves there. Short-term intervention may be required, but a prior cost-benefit analysis is recommended.

Other coastal vegetation has been visibly impacted at many locations. The severity of the impact is increased in situations where the bordering beach and foreshore are narrow, either naturally or by previous erosion. The impacts consist mostly of uprooted plants at the beach crest or exposed root systems. As most beach crest and coastal vegetation is salt tolerant long-term impacts are not expected. The role of beach crest and coastal vegetation was very important in reducing the impact of the tsunami wave, due to sediment stabilization, sand trapping and wave attenuation. The maintenance and extension of areas of mangroves and coastal vegetation is of importance to reduce the vulnerability of the coastal zone for erosion and impacts of calamitous events.

Turtle Nesting Sites

The Seychelles is a critical habitat for sea turtles, listed as endangered on the IUCN Red List. Significant populations of the green (*Chelonia mydas*) and hawksbill (*Eretmochyles imbricata*) turtles commonly use beaches for nesting. Sea turtle nesting sites are located on many of the beaches around the inner Seychelles islands. As such, they are vulnerable to erosion of the upper beach noted above. The peak nesting season for hawksbill turtles is December to February. Fortunately the highly eroded beaches (e.g. Kerlan, Anse Royal), were not highly important as nesting sites, and direct exposure of turtle eggs was only reported for two nests from Curieuse Marine Park. Turtle monitoring programmes from other islands, including Aldabra, Farquhar, D'Arros, St. Joseph, Bird and Aride islands indicated no known damage.

At Anse Cimetiere, Curieuse, high beach erosion is normal at this time of year. In Curieuse Marine Park, at least two hawksbill turtle nests were flooded and eggs exposed. Although a number of these eggs were recovered and reburied by rangers, such incidents may have occurred on other beaches where park staff were not present. Long-term impacts on nesting activity need to be monitored. Reports from Cousin Island show that turtles stayed off the beaches from 26-27 December 2004.

Case study: Coastal erosion on Praslin Island

Few people realise that the tsunami can turn corners. Praslin, the second largest island on Seychelles, was badly affected on the west as well as the east coast. The first sign along 2km Anse Kerlan (Kerlan Bay) was a massive tidal retreat as the tsunami pulled water away from the island. When the returning waves struck they flooded over the dunes, toppling trees, damaging houses and destroying garden crops. As they retreated, the waves dragged up to 200,000 cubic metres of sand out to sea, leaving a steep erosion cliff up to 2.5m high in places.

Anse Kerlan, is not only a popular beach for tourists and local people, but also for nesting Hawksbill and Green Turtles. The erosion of the beach threatens protective vegetation, soils, housing and turtle nests. Action is essential to prevent further loss of sand in the north-west monsoon season.

Hydrodynamic studies are needed in order to recommend either building of groynes (which could affect the turtles) or replenishment of lost sand. More immediately, the authorities must restore the coastal vegetation and instigate a regular monitoring programme. Training and capacity-building are essential.



Anse Kerlan, Seychelles (5 February 2005). Eroded turtle nesting beach.
© Mark Collins/UNEP

Estuaries and Wetlands

Estuaries and wetlands found in the Seychelles are limited in area, due to the steep geography and therefore limited extent of the coastal plains. Wetlands have been gradually utilised by agriculture or reclaimed for infrastructure. Non-mangrove wetlands in the coastal plains have been directly hit by the tsunami causing salinization of surface water and groundwater. Heavy rains that followed the tsunami have probably flushed a considerable amount of salt out of these systems. Immediate impacts to vegetation can be seen in yellowing or shedding of leaves of herbs, shrubs and trees. Long-term impacts are not expected due to naturally intensive flushing of these systems with fresh water. Wetlands are rare in the Seychelles and perform important functions in water storage and safeguarding of biodiversity.

Surface and Groundwater

All the islands in the Seychelles rely on surface water. Groundwater is only used to augment water supply during the dry seasons in La Digue Island. The impact of the tsunami on groundwater has not been assessed. However, the Crop Development and Promotions Division reported an increase in groundwater levels of mostly saline water in the coastal areas, just after the tsunami and before the torrential rains.

Soils and Agriculture

The salt water that flooded the shore undoubtedly washed away nutrients and increased the salt content of the soil. The torrential rainfall would have leached salt from the soil, though parts of Victoria still had a high salt content of 1.2 per cent. This is double the amount most plants in the Seychelles can tolerate. Sodium also destroys soil structure, thereby reducing infiltration rate. This might have contributed to the flooding in coastal areas caused by the torrential rains that fell a day after the tsunami.

Many ornamental plants and food crops were affected either by force of the seawater surge or by exposure to saline water. Ornamental palms in Victoria including those previously believed to be salt tolerant died and had to be replaced. Leguminous trees and herbaceous trees also died immediately. Of the palms only *Pitchodia pacifica* was not affected.

Though the tsunami caused some damage to agriculture, the effect of the torrential rains which followed was more devastating. Damage caused by the tsunami on eight farms has been estimated at SR 375,852 ($70,000) and that from the torrential rains was on 36 farms and estimated at SR 1,345,773 ($250,000).

Marine and Terrestrial Protected Areas

At present marine parks occupy about 10 per cent of the area of the continental shelf, generally occupying the nearshore of the islands. The principal impacted marine areas were found within the marine protected areas of the Seychelles. Sites in the Baie Ternaie Marine Park, and Anse Cemitiere in the St. Anne Marine Park (Mahé) and Curieuse Marine Park suffered the highest damage from the wave impacts and subsequent silt deposition on the reefs and sea grass beds. Inshore and terrestrial protected areas such as the proposed Ramsar site at Port Laumay were not significantly affected.

6.4 Preliminary Findings: Impacts on the Human Environment

Over 90 per cent of the Seychelles population lives on the granitic islands of Mahé and Praslin. There are two distinct zones on these islands: the hillsides and the coastal plain. Most development, such as industries, hotels, schools and houses, is on the coastal plains. The government policy of discouraging development on the hillside because of erosion and resulting landslides, will increase the infrastructure in the coastal zone which is also very vulnerable to tsunamis and other tidal waves.

Industrial Sites, Power Plants and Ports

The damage sustained by the ports infrastructure was mostly at Victoria Port. Two sea walls collapsed, five quays had wide cracks along their structure and the internal fittings of some fish processing factories were damaged as a result of the massive waves. Besides the rubble, there were no reports of any contaminants released into the environment even from flooding of factory premises. Any waste generated was disposed of within the normal waste disposal stream. For example, the 24 tons of contaminated fish at Oceana Fisheries was used to prepare stock feed, in line with the waste management practice of the country.

Sewage, Debris and Solid Waste

The discharge of raw sewage into some marshes and the lagoon for 10 days was the biggest water pollution incident. The violent and sudden reversal of the waves and backwash caused the failure of the Roche Caiman Bridge. This bridge provides support to a 500 millimetre-diameter sewer conveying sewage from Victoria to the treatment works at Provident. As a result, the sewer line broke and spilt raw sewage into the lagoon. Another 150 millimetre-sewer rising main from Roche Camain Stage II was also affected.



Mahé, Seychelles (26 December 2004). People assess the damage after the tsunami hit the Seychelles capital Mahé. Seawater surges flooded the low lying areas of Mahé, Praslin and La Digue and caused widespread damage to beaches, coastal vegetation, roads, bridges, houses and other infrastructure. The tsunami was followed on 27 December by extreme weather, with rainfall reaching 250 millimetres in the northern and central areas of Mahé. Torrential rains continued for several days, causing further damage to infrastructure, dwellings and vegetation. © Terence Fortune/Reuters

Because sewage could no longer be pumped to the treatment works, raw sewage also overflowed at the pump stations. The effect of the discharge was not assessed as the high dilution factor in the lagoons is believed to have lessened the adverse impact on the environment. Because the sewer requires the support from the bridge, it could only be repaired after the bridge had been rebuilt. This took 10 days during which residents were informed of the threat and advised to take basic hygiene precautions.

The solid wastes generated as a result of the tsunami were mostly debris from broken structures. Most of the damage came from Mahé and Praslin islands and to a lesser extent La Digue. In residential areas along the coast, the tsunami caused extensive structural damage to five schools, about 100 houses, sports facilities, rock armouring, sea walls and five bridges. This generated 296 tons of debris which cost SR 82,500 ($15,500) to dispose of.

Apart from the damage to two bin sites and ten bins there were no reports of pollution from litter. Assessments carried out after the tsunami in coral reefs, did not show any litter in the water. However, there are reports of increased litter observed in Aldabra after the tsunami.

Water Supply

The incoming waves swept debris, dead trees and sand into drains. This blocked the system which drains water from inland. Seychelles has a chronic erosion problem which causes landslides in the hillsides. As the tsunami was closely followed by torrential rainfall, the blocked drains and the high silt load from the hillside, resulted in big floods on the coastal plains. A total of 8,947 metres of drains costing SR 800,000 ($150,000) needed desilting.

The collapse of another bridge, at Anse La Mouche and that of the Roche Caiman broke water supply pipes which convey water from the Desalination Works to Hermitage reservoir and to the East Coast Reclamation area. The outer islands (Cerf, Round, Long, Moyenne and St Anne) are all provided with water from the east coast of Mahé through a submarine pipe. The tsunami caused the submarine pipe to move laterally causing abrasion, rupturing the pipe. The Public Utility Corporation provided temporary connection for the water supply.

Impact on Fisheries

In the weeks following the tsunami, fish supply in the markets was low. However, this was due to damage to the fishing fleet, and no reports of reduced fishery productivity have been received.

6.5 Preliminary Results: Environmental Management Capacity

Environmental Monitoring

The Seychelles covers a large oceanic area of some 1.3 million square kilometres, with a central core of granitic islands and dispersed outer islands. The increasing severity and variety of extreme events (cyclones, heavy rains, El Niño events and now the tsunami) puts these small island systems at increasing risk and necessitates the expansion and strengthening of environmental monitoring capacity at the national level. With climate change, three specific risks are increasing in the Seychelles. First, the cyclone belt is widening and is approaching the equator and the Seychelles (5 – 10° S). Second, sea level rise is accelerating and finally, increased sea surface temperatures have already caused a first round of catastrophic coral bleaching in the country. None of these risk factors are sufficiently recorded by the present monitoring capacity in the Seychelles, which was degraded by the tsunami. Improved monitoring capacity in the Seychelles will play not only a national, but an international role, as the country straddles a broad swathe of the central Indian Ocean.

Case study: Environmental Risk to the People of Victoria, Seychelles



Victoria, on the east coast of Mahé, the largest island in the Seychelles, took the full force of the tsunami. In addition to major impacts on bridges, roads, port facilities and boats in the harbour, the seawater was driven hundred of meters up into the city drainage system, blocking pipes with silt and flooding roads, shops and houses. Blocked pipes, drains and culverts slowed the return of the water to the sea, causing severe losses to business and expensive destruction of public amenities, landscaping, parks and gardens.

The risk of pollution with sewage consequent spread of disease across the city centre met with an immediate response from the city authorities, but there is now a need for planning and reconstruction to meet the challenge of the increasing number of ecological disasters.

In addition to immediate repairs, maintenance and improvements to sewerage systems, the government is developing a master drainage scheme, creating a national database on hydrology, and evaluating the importance of marshlands and rainwater harvesting in water and drainage management. In total, repairs and improvements to drainage in Mahé will cost more than US$2 million.

Building and restoring monitoring capacity should incorporate multiple levels, including physical (sea level and tides, air and sea temperature, winds, etc), biological (coral reefs, plankton, pelagic and fishery resources, coastal vegetation, mangroves and terrestrial flora and fauna) and socio-economic (vulnerability indices, water supply, resource use, etc) levels. Additionally, strategic alliances combining government and non-government (private sector) monitoring initiatives need to be strengthened, especially with the challenge of maintaining information flow from the dispersed outer islands and extensive oceanic areas. Developing sustainable capacity for monitoring that is largely self-sufficient is critical to the long-term integrity of the system. Of critical importance is the role of the Marine Parks Authority in monitoring the health of marine ecosystems as indicators of the general status of the islands and to maintain their health as important protective barriers and economic resources.

The tsunami damaged the tidal gauge station of the Meteorological Service, located near the International Airport. Also damaged was key infrastructure of the MPA such as moorings. Some monitoring equipment was lost. Monitoring capacity was also damaged in other areas immediately following the tsunami; the heavy rains damaged the four main meteorological stations in Mahé and the station in Praslin and the 35 rainfall stations. They were, however, repaired within a month, underlining the importance of building self-sufficiency in monitoring and disaster response capability in the country.

Environmental Framework Laws

Long-term government plans for an integrated coastal zone management strategy (ICZM) will include a comprehensive legal framework, but this is not yet in place. Coastal zones are currently covered by various regulations, including the Beach Control Act, covering the use of resources and different activities between high and low water mark, and the Town & Country Planning Act. The commonly used 25 metre set-back regulation has no legislative backing. It is too rigid and should apply as a minimum applicable to coastal areas of low sensitivity. More sensitive areas should adopt larger set back widths in light of recent experience. Moreover the set back regulation should be upgraded to a law, in order to protect the coastal zone more effectively.

Bearing in mind the impact of actions inland on coastal ecosystems, forest management laws, now 60 or more years old, may need reform to embrace the environmental impacts of forestry and deforestation on the coastal zone.

In urban areas, the 1994 Environmental Protection Act, covering waste management, pollution and sewage, appears to have served Seychelles well during the recent tsunami. EIA is required for all developments, at various levels of detail.

At the international level, the Seychelles is party to the Conventions on Biological Diversity, World Heritage, Migratory Species, International Trade in Endangered Species and the Ramsar Convention on Wetlands of International Importance. A Biodiversity Act, currently under development, is foreseen as providing the enabling legislation for these conventions and additional technical support might be desirable.

Coastal Zone Management

Solving complex, interrelated problems in the coastal zone requires an holistic vision on coastal processes, both natural as well as socio-economic. The vertical and horizontal integration of effort is facilitated by institutional strengthening of the national, district and local authorities, applied scientists and stakeholders. To date there is no high level, coordinating National Committee for ICZM. Its establishment should be considered in order to improve coordination and integrated decision-making. This National Committee could also play an important coordinating role in tying together the challenges and solutions of the interrelated zones: the mountains, rivers, coasts and reefs. Such coordination could also strengthen

the linkage between the implementation of international conventions such as Convention on Biological Diversity and the UN Framework Convention on Climate Change.

A legal framework for ICZM including a national ICZM plan is not available. At present coastal legislation and activities by the various stakeholders is fragmented and has perverse effects on the sustainable development of coastal resources.

The CZM-Unit within MOE is at present coordinating a limited number of activities, solely related to coastal erosion and adaptive measures. The tasks of the CZM-Unit should be enlarged to a wider scope in order to prepare for functioning as a technical secretariat for a future National Committee for ICZM. The CZM-Unit should be enlarged through increases of human resources and of technical capabilities.

Early Warning and Awareness Raising

The Meteorological Service is responsible for early warning. However, their monitoring capacity is extremely limited. Fundamental needs include equipment for monitoring water levels, waves and sea surface temperature, training of personnel and linkages to international meteorological organisations for coordination. At the same time, an increase in the public awareness of hazards is needed, specifically geared to schoolchildren.

Disaster Management

For about twenty years after independence, the Seychelles islands were fortunate in escaping major environmental and natural hazards. That situation changed when the 1997 El Nino floods struck the Seychelles, raising public and government awareness about the necessity of strategic disaster management. The President's Office revitalised the National Disaster Management Committee, which was asked to prepare a National Disaster Response Plan (NDRP). The Ministry of Environment and Natural Resources was given the lead. In September 2002, a strong tropical storm caused major damage to the environment and tourism, prompting the Ministry to request additional capacity from UNEP and the UN Office for Coordination of Humanitarian Affairs (OCHA). The results of the joint UNEP/OCHA Seychelles assessment (March 2003) highlighted the need to finalise and implement the NDRP drafted a few years before. In 2004, a second UNEP mission to Seychelles was asked by the Office of the President to focus on preparation of a National Strategy for Risk and Disaster Management. A draft document was prepared in 2004 and is in final stages of completion and printing.

Turning to the question of capacity for disaster management, in October 2004 Seychelles created a National Disaster Secretariat under the management of Michel Vieille, Director for Risk and Disaster Management. The Secretariat acts as the operational arm of the National Disaster Committee, but as yet has no additional staff, nor basic equipment for operations. There is a serious need for capacity-building estimated to cost $250,000 over five years.

Utilizing Local Knowledge

The limited field assessments carried out revealed little evidence of local techniques for coastal zone management, but this aspect is worthy of closer investigation. In certain areas, such as Anse Royale, coconut-leaf walls are constructed to protect the coast. In other areas of the western Indian Ocean coconut fibre, mangrove stakes, stone walls and sandbags have also been used locally and to good effect.

In the outer islands of the Seychelles, local people and organisations should be more involved in the monitoring and early warning programmes using improved means of communication. Estimated costs for mobilising local knowledge are $25,000 annually.

6.6 Recommendations

The following conclusions were based on site visits and discussions with Seychelles organizations.

The tsunami damage in the Seychelles is extensive on a national level. The response of authorities has been speedy and thorough, thereby limiting knock-on impact. It is especially relevant to mention the inherent limitations of the small scale of island resources. Government disaster management programmes have shown resilience during the tsunami but were stretched to the limit of local operational capabilities. Good waste management has limited the load of waste and pollution to the sea.

Team members have observed that management of the coastal vegetation has been effective in reducing the impacts of the tsunami. Maintaining the health and extent of coastal vegetation is therefore important for mitigation of future hazards.

The tsunami impact is recognized as only one part of a sequence of human and natural induced hazards, and in particular coral reef damage was minimal in relation to the large, catastrophic impacts of coral bleaching in 1997/8. Reports of other natural hazards occurring in the Seychelles indicate significant additional threats to humans and to the island ecosystems.

Activities for the Short Term

In the short term (starting 2005) the following actions are proposed in support of early warning, assessment and monitoring, together with urgent repairs to protect coastlines:

- Undertake a detailed environmental assessment of the impacts in order to establish the current environmental baseline, as well as to provide inputs to land use planning and reconstruction.
- Assess and repair as appropriate the damage to Curieuse Island causeway. If this is to be done it will be essential to do it before the next South-East monsoon in April 2005, when wave damage to the mangrove communities will intensify.
- Restoration of marine parks infrastructure (mooring buoys, patrolling and monitoring equipment) to maintain the ecological and tourist infrastructure.
- Mitigate beach erosion and repair damage to protective infrastructure in the coastal zone as much as possible using soft solutions such as beach nourishment.
- Intensify monitoring beach profiles in selected erosion prone locations.
- Strengthen nearshore marine habitat mapping to establish impacted areas and rates of recovery. Integrate onshore damage and marine habitat information to assess the spatial relationship between shoreline damage and location of protective ecosystems.
- Reiterate and strictly apply existing rules on setback lines for coastal zone development, in order not to further degrade the resilience of the coast.
- Identify areas vulnerable to soil erosion. Undertake efforts to stabilize hillsides and to maintain forest cover in order to reduce loss of topsoil and impact of silt on coastal ecosystems.
- Develop and start implementing Integrated Coastal Zone Management Plans for each island taking into account dynamic coastal processes, coastal ecosystems and location of uses in the coastal zone, linking of marine and terrestrial ecosystems (including steep hill areas), through integrating ICZM and MPA management plans.
- Development of a national policy for early warning and disaster management that incorporates cross-cutting roles of government agencies, collaboration with the private sector and reductions in vulnerability of the national economy and coastal communities to ocean risks.

Activities for the Medium to Long Term

- Implement capacity building programmes in order to reach self sufficiency in coping with hazards and managing the natural ecosystems of the islands.

- Strengthening exchange of knowledge and management experience between SIDS and states bordering the Indian Ocean.
- Develop improved drainage schemes. Implement management of wetlands to cope with water storage and reduction of flooding in combination with forest and hillside land-use management in order to reduce loss of topsoil. Analysis of water drainage, slopes, forest management and the role of infrastructure on hillside erosion and flooding of the coastal plains.
- Development and implementation of long term monitoring programmes (physical processes, ecosystem state, land-use state).
- Address stability issues of the coastline.
- Development of a national policy for Marine Protected Areas and ICZM that recognizes the protective function of coral reefs and maximizes protection and conservation in the long term.

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YEMEN



Dabut, Yemen (28 December 2004). A man stands among the rubble of Dabut market, Yemen. The main direct impact of the tsunami in Yemen was on the fishing sector.
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7. NATIONAL RAPID ENVIRONMENTAL ASSESSMENT – YEMEN

7.1 Introduction

The 26 December tsunami wave and subsequent sea surges hit the coast of Yemen between 11.40 a.m. and 8.30 pm., causing damage to Yemen's mainland and associated islands facing the Indian Ocean. Local observations indicate that water started to rise at about 11:00 a.m. local time on 26 December 2004. The water level receded in some locations (such as Muhaifif in Al Mahra), exposing about two kilometres of the sub-tidal flats before flooding in.

Relative to the countries of southeast Asia, damage in Yemen was much less, mainly because of its distance from the epicentre of the earthquake, and the protection it receives from the Indian Peninsula and Horn of Africa. Nevertheless, the impacts on the livelihoods of local people, especially fishermen, were significant, as many of them lost their main form of income. The two main areas identified as the most affected include Socotra Island and the coastline of Al Mahra Governorate, especially the area extending from Saihut to Wadi Hauf.



Dabut, Yemen (28 December 2004). Relative to the countries of southeast Asia, damage in Yemen was much less, mainly because of its distance from the epicentre of the earthquake, and the protection it receives from the Indian Peninsula and Horn of Africa. Nevertheless, the impacts on the livelihoods of local people, especially fishermen, were significant, as many of them lost their main form of income. © Al Mahra Rural Development Project

7.2 Overview of Environmental Response

In the weeks following the disaster, UNEP received a request from the Ministry of Water Resources and Environment in Yemen for technical and financial assistance in conducting an assessment of the impacts of the tsunami on the marine environment. The request also included capacity building measures for capacity building of the Environmental Emergency Unit in the Ministry of Water and Environment, and inclusion of Yemen in any regional or global early warning system to address natural hazards.

As the first stage in responding to this request, UNEP organized a fact-finding mission to Yemen between 5 and 11 February 2005. Based on the findings of the mission, a more detailed technical assessment is planned to be conducted in March 2005 to collect additional information as well as to conduct a detailed impact analysis.

The principal coordinating partner in the assessment process is the Ministry of Water and Environment. Other ministries have also taken lead roles in their respective sectors including the Ministry of Fish Wealth, the Ministry of Transport, and the Ministry of Local Administration/Islands Development Authority. Additional partners included the Conservation and Development Project (SCDP), the Governorate of Al-Mahra, various local communities and a volunteer from IUCN stationed in Socotra.

The duration of the mission was quite short and much time was spent in travel to reach the affected sites, thus allowing very limited time for field assessment. Access to the Socotra sites was very difficult. As a result, the assessment could not include a sub-marine investigation of marine resources as there was insufficient time to organize diving at the affected sites. Additional work is clearly needed in this area. In Socotra, the sites visited were Mahfirin (most affected area), Khawr Matyif (second affected area), and Omouk (at this site, no significant damage could be established in the field). Other key sites that were not visited are the headlands to the east (Riy Di Irisseyl) and west (Riy Di Shu'ub), in addition to Qalansiyah, where a five-year old child was reported to have drowned.

7.3 Preliminary Findings: Impacts on the Natural Environment

The coastline of Yemen is over 2,100 kilometres long and comprises three coastal regions: the Red Sea, Gulf of Eden, and the Arabian Sea. The Red Sea region covers about one third of the length of this coastline, with the remainder bordering the Gulf of Eden region.

There is a high reliance on natural resources such as fishing and agriculture in the coastal areas of Yemen. The sustainable use of these resources is linked to public health, food security and economic and social benefits including cultural values and traditional livelihoods. In addition to fisheries and agriculture, tourism is increasing as a source of income in coastal regions of the country. A large portion of the coastal population in Yemen, particularly in Socotra, live in a subsistence economy. They are, therefore, particularly vulnerable to environmental change, decreasing productivity of the coastal ecosystem, extreme weather events and natural catastrophes such as storms, heavy rains, and tsunamis.

Marine and Coastal Ecosystems

The marine environment of Socotra and the coast of mainland Yemen are influenced by the monsoon winds. As a result of the strong up-welling, the inter-tidal and sub-tidal ecosystems are subjected to drastic changes of the physical and chemical parameters which create a rare ecosystem with a large diversity, particularly among algal/seaweed species. The is a high abundance of fish, particularly in the Gulf of Aden, which sustains local livelihoods.

No studies have been conducted to assess the impacts of the tsunami on the marine ecosystems of Socotra and Al Maharah. However, Socotra has relatively large amount of background data as a result of a recently concluded GEF-project and by other projects supported by IUCN, other agencies and organizations. Therefore, a follow-up investigation should be deployed to revisit sites that have been studied previously and that are located in the area affected by the tsunami. A monitoring programme of inter-tidal and sub-tidal sites is also on-going in Socotra. During the UNEP mission, discussions were held regarding the need for an extension of the monitoring in order to particularly target any impacts from the tsunami. It was found that such targeted studies should be performed and the recently produced IUCN "Guidelines for Tsunami Damage Assessment on Coral Reefs" was provided to the local SCDP team.

Priority Ecosystems and Protected Areas in Yemen



	Total Area km	Potential Area Impacted km
Coral Reefs	844	NA
Mangroves	288	NA
Protected Areas	3,628	NA

website: www.unep wcmc.org

please contact Kaveh Zahedi or Phillip Fox for further details

All data on Protected Areas, Coral Reefs, Seagrasses and Mangroves are available from UNEP WCMC databases.
Data on population density kindly provided by CIESIN.

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Due to time constraints, the UNEP-team did not have an opportunity to carry out a dive assessment during the visit to the southeast coast of Socotra. However, visits to the coastal area affected by the tsunami (see below for description of the impacts on the fishing communities) showed what appeared to be beach erosion and possibly altered beach profiles. The sand at the landing site in the village of Mahferhin has been washed away and left a beach consisting of stones and cobbles. These observations were also confirmed by the local fishermen at the site.

From Al Mahrah, there are no available background data from studies in the littoral and sub-littoral areas. In the absence of background site information, a follow-up study of the impacts in the marine environment therefore appears less meaningful than in Socotra. However, an investigation without baseline information may reveal damage in the form of broken and over-turned coral, debris on reefs etc. To be meaningful such an assessment should be carried out relatively soon after the incident.

Surface and Groundwater

Reports from villagers along the southeast coast mentioned increased salinity in groundwater wells as a problem. Wells on the coast initially had a low level of salinity and the water from the wells was used for washing, bathing, watering planted palm trees, and to a very limited extent for drinking. This water now has a high level of salinity and cannot be used at all. The number of wells affected could not be established but is believed to exceed ten. However, considering the fact that the tsunami penetrated up to 400 metres inland, groundwater reservoirs may have been affected and this may render some wells unusable for coastal communities for some time. A programme to sample and analyse ground waters from different parts of Socotra is planned by SCDP/Ministry of Water and Environment.

Coastal Erosion

There is some evidence of damage to the coastline. For example, in Dabut fishing centre, areas originally covered with sand have been exposed and are now stony surfaces. This is attributed to the tsunami and earlier coastal erosion.

7.4 Preliminary Findings: Impacts on the Human Environment

Impacts on Livelihoods

Fishing and the fisheries sector plays an important role in Yemeni society. The sector provides food security and employment. Fisheries statistics in Yemen, as in many other countries, are unreliable. In total, the catch figures reported by the Ministry of Fish Wealth range from 150,000 to 228,000 tonnes per year. About 60 per cent of the total catch comes from the two Governorates Al Maharah and Hadramout. Smuggling of fish out of the country as well as illegal fishing by boats from other countries is reported as a problem. About 50,000 persons are reported as fishermen in the national statistics. In the Al Mahrah Governorate, according to the official statistics, there are about 1,500 fishermen. However other figures quoted during the UNEP mission puts the number at about 6,000. There are about 700 fishing vessels in Al Mahrah. Fishing is mostly carried out from relatively small fibreglass boats (13–15 metres long) with an inboard or outboard engine.

The main direct impact of the tsunami in Yemen was on the fishing sector. However, in Al Mahrah some other sectors were affected to some extent. In Al Mahrah the coastal area between Saihut and Hauf near the Omani boarder (particularly the fishing villages of Muhayfif, Yeroub and Nashtoun) experienced a strong tsunami wave (a 6 m high wave penetrated 400–500 metres inland at Muhayfif), which destroyed houses and other facilities on the beaches, destroyed and lifted boats several hundred metres inland and destroyed fishing gear. As far as is known at present, in Socotra primarily the coast between Omouk, Mahferhin and Matyif in the southeast of the island was affected. Floods also covered agricultural land near the coast, destroying fences and crops, and depositing salt on the soil.



Muhayfif, Yemen (28 December 2004). Tsunami debris outside the offices of the Al Mahra Fisheries Association.
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The following damage to human economic activities including the fisheries sector has been reported:

Table 1 Summary of damage to fisheries sector

	Al Mahrah	Socotra
Fishing nets and longlines	500 nets	174 nets 37 hook lines
Fishing traps	9,500	486
Fishing boats	33 (totally destroyed) 108 (partly destroyed)	16 boats 143 ropes 260 anchors, buoys and other equipment
Outboard engines	33 (totally destroyed) 106 (partly destroyed)	36 engines 10 fuel tanks
Fisheries facilities	Fish market stands and a 146m long wall, ice plant, Fisheries Cooperative storage area	23 petrol drums, 45 sacks of salt
Other buildings	Masjid, gas station,	
Vehicles	5 cars, motorcycles	

Case study: Ghost nets roaming the seas

Ghost nets are fishing nets that have been abandoned in the marine environment and which continue to harm marine life. They kill fish, marine mammals, and seabirds as well as destroy habitat. Lost gill nets are extremely lethal because of the ease with which organisms become entangled in them. Entangled organisms then become bait for predators which also get caught in the nets. The nets become a perpetual killing machine, and only stop once their structural integrity begins to disintegrate. With new synthetic materials, this could take decades, and the fish mortality caused over the lifetime of a single net could be in the hundreds of thousands. In addition, the lead lines associated with nets are pushed by the tide and scrape away sea grass beds and other marine habitat causing additional damage.

The issue of ghost nets was specifically raised as an environmental concern during the UNEP mission to Yemen. In the Governorate of Al Mahra alone, 500 fishing nets, 1,500 octopus traps and 8,000 lobster traps were lost to sea. Fishermen on the Island of Socotra also lost approximately 174 fishing nets and 37 hook lines. However, the largest possible source of ghost nets will most likely come from Sri Lanka and Indonesia where tens of thousands of nets may have been swept out to sea.



Grey reef shark, Andaman Sea (undated file picture). Fishing nets that have been abandoned in the marine environment, known as ghost nets, kill fish, marine mammals and seabirds, and destroy habitat. In Yemen alone, hundreds of nets and octopus and lobster traps were washed out to sea, where they could continue to harm the environment for years to come. Fred Bavendam/Still Pictures

The total value of the damages in Al Mahrah (excluding automobiles) and Socotra has been estimated by the authorities at approximately 170,000,000 YR ($935,000) and ($175,000) respectively. Two agricultural farms on the coast (area not established) were completely lost. These were involved in growing crops and palm trees.

Ports and Industry

According to the Minister of Transport, the main ports of Yemen did not suffer damage, even though water levels in the ports rose an average of 60 centimetres for several hours during the period of the tsunami waves. No industrial facility was recorded to have been affected by the tsunami waves.

In addition to the above-mentioned areas, there were also reports from the Governorate of Aden that one fishermen died and five others injured.

Waste Management

Tsunami-generated debris is strewn all over the coastline especially within the fishing centres. The waste mainly consists of damaged nets, beached boats and canoes, lobster and octopus traps, concrete slabs, wood, dead fish, plastic bottles and diesel containers, and other materials. The local authorities have tried their best to collect this debris and pile it, but proper disposal is needed. This can be done with limited guidance. A number of barrels of fuel (petrol and diesel), tins of paint and other chemicals were washed out to sea. In Mahaifif alone, it is estimated that ten 200-litre barrels of fuel and about 350 litres of paint were washed out to sea. These are believed to have been naturally dispersed.

Water and Sanitation

None of the fishing centres on the coast have proper sanitation systems. Water deposited by the tsunami in depressions within these areas is spreading bad odours in the area. Stagnant water poses a health hazard to the fishing communities operating from these centres.

7.5 Preliminary Findings: Environmental Management Capacity

Environmental Framework Laws

Yemen has established a strong framework for environmental work. Since 1990, the Yemeni Government has established a number of national laws and regulations that concern and relate to the coastal and marine environment under responsibility of several agencies.

Environmental management laws and institutions in Yemen

The key environmental management laws in Yemen include:

- Presidential Resolution No. 275 of 2000 (Master Plan of Socotra
- Archipelago).
- Law No.4 of 2000 (Duties of Local Governments).
- Law No. 39 of 1999 (Cleaning and Improvement of Cities).
- Law No. 25 of 1999 (Regulating and Handling of Pesticides).
- Law No. 1 of 1995 (Common Benefit).
- Law No. 20 of 1995 (Urban Planning Procedures)
- Law No. 21 of 1995 (Land and Real Estate).
- Law No. 26 of 1995 (Environment Protection).
- Prime Ministerial Decree No. 4 of 1996 (Establishment of Protected Areas in Socotra).
- Law No. 15 of 1994 (Ship Registration, Documentation, Monitoring).

- Prime Ministerial Decree No. 23 of 1994 (Validation and Penalties).
- Law No. 4 of 1993 (Free Zone Law).
- Law No 11 of 1993 (Protection of the Marine Environment from Pollution).
- Law No. 37 of 1991 (Territorial Waters and the Exclusive Economic zones).
- Law No. 42 of 1991.

Authorities and institutions working under the umbrella of different ministries on issues related to coastal and marine environment include:

1. Environment Protection Authority (EPA).
2. Tourism Development Authority (TDA).
3. Maritime Affairs Authority (MAA).
4. Maritime Training Centre (MTC).
5. General Corporation for Development and Promotion of Yemeni Islands (GCDPI).
6. Marine Science and Resources Research Centre (MSRRC).
7. Coast Guard Authority (CGA).
8. High Council for Urban Planning (HCUP).
9. Faculty of Oceanography and Environment, Al-Hudyadah University.
10. Faculty of Environment and Marine Biology, Hadramout University.
11. Department of Earth and Environmental Science, University of Sana'a.
12. Environmental Research and Studies Division, University of Aden.

Staff of Socotra Conservation and Development Programme indicated that Law 26 of 1995 (Environment Protection) is one of the most applicable and used laws in Socotra, this is followed by Law 11 (Protection of the Marine Environment from Pollution).

While Yemen has developed laws and regulations dealing with various aspects of the environment including the coastal zone and marine areas, the country faces a number of obstacles to implement its legislation. There are a number of overlapping and contradictory functions vested in different authorities, and in most cases there is insufficient capacity to carry-out agency mandates. Environmental monitoring and enforcement are key problems.

Unlike severely affected countries in South East Asia, the tsunami did not impact the existing institutional capacity for environmental management, with almost no damage to staff, facilities or equipment.

Environmental Impact Assessment

Environmental impact assessment (EIA) is mandated in Yemen by Law No 26 of 1995. All projects have to conduct EIA studies before being approved. This applies to projects undertaken in coastal and marine areas. There is a Unit in the Environment Protection Authority that oversees these studies and ensures they are undertaken before project approval. Sub-national units are also established in some parts of the country. For example, the SCDP has established a new EIA Unit. However, lack of by-laws, lack of expertise, inadequate human and financial resources hinder strict application of EIA.

Coastal Zone Management

The coastal zone in Yemen is not yet well developed, except in a few cities such as Aden. According to the 1994 census, the total population of the coastal areas of Yemen was less than 2 million distributed over nine Governorates or 2,100 kilometres of coastline. Yemen recognizes that with the increasing need for development of the coastal zone, integrated coastal zone management has become a necessity. Coastal zone management has been applied in some areas in Yemen. In Socotra, for example, recent developments included an airport, a port jetty, the first asphalted road, schools, fuel storage facilities, better

telecommunication facilities, and improved power supply. For such developments, a zoning plan for Socotra was finalized in October 1999. The process was accomplished by engaging the local community in the development of the plan, including women.

The overall low development in the coastal zone in Yemen was a factor reflected in the limited impact of the tsunami on human lives, and properties. With increasing demand for development of the coastal zone, integrated coastal zone management will be necessary to ensure that people and property are not located in harm's way.

Early Warning

There are some early warning activities in Yemen. The Ministry of Agriculture and Irrigation in coordination with National Water Resources Authorities, in association with the Ministry of Water Resources and Environment is the main governmental body for monitoring and management of early warning systems for floods. This system is only active in limited areas in the western highlands in the country.

Most early warning systems originally established by projects funded by international organizations could not continue as soon as international support ended. The main reason for this halting is that there is no clear mechanism to regulate and control these issues.

There are information departments in many relevant ministries. However, there are no integrated national environmental and early information systems which could provide timely integrated data in case of an environmental emergency.

Disaster Management

In addition to the tsunami disaster, Yemen has experienced different types of disasters that also had severe impacts, including flash floods, earthquakes, drought, locusts, oil spills, red tides, civil war, and epidemics of communicable diseases. In 1999 alone, it is estimated that about 19,782 persons were affected by disasters in Yemen.

No policy or legislation on a national level has been implemented to address disaster reduction. However, since 1996, the issue of strengthening and establishing a disaster management policy and responsible entity received greater attention from the Government. In this direction, the Government took many steps including decrees on civil defence law for effective disaster management, forming a committee to prepare a national approach for disaster management, and issuing the Civil Defence By-Law. This is in addition to many other related laws. Yemen also established a national body for multi-sectoral coordination and collaboration in disaster risk reduction, known as the Civil Defence Council (CDC). The CDC includes the key ministries concerned.

In 2003, the Ministry of Water Resources and Environment established the Environmental Emergency Unit (EEU) to participate in and coordinate with stakeholders for the preparation of a national environmental disaster strategy, and to coordinate the management of disasters. It is establishing a national response team from focal points from relevant governmental and NGO agencies to implement the unit's mandates on environmental emergencies and disasters. However, the Unit lacks capacity to handle environmental emergencies. There is also poor coordination among the focal points in the county, and there is need to clarify the mandate of the CDC.

Local Ecological Knowledge

Local people in Yemen in general and in Socotra in particular have strong traditional rules to protect the marine and terrestrial natural resources they rely upon. Such traditional rules are still enforced by the local village councils. This remains the case in Socotra, but on the mainland the tradition has started to erode as daily pressures increase while financial resources are limited.

7.6 Conclusions and Recommendations

Assessment and Rehabilitation of Natural Resources

A more elaborate and detailed study on the impact of the tsunami on natural resources in the affected sites, is strongly recommended. More specifically, the sub-marine habitats and ecosystems should be studied to determine long-term impacts, and whether there is a need for rehabilitation efforts for these resources. This study should be undertaken within the next three months.

External support should be provided to concerned authorities and institutions (such as the Socotra Conservation and Development Programme) to undertake such a study, with the help of international experts, and provision of necessary equipment such as underwater video camera, compressor, and deep-water diving gear.

Baseline Survey and Monitoring

As a long-term project, there is need for a baseline survey of environmental resources along the Yemeni coastline. The baseline survey should also result in a cost-effective environmental monitoring system. After the tsunami and in the absence of data and information there is no adequate basis for comparison, even if a full assessment is to be conducted. Also, not much is known about the threats to the resources and the regulations that need to be instituted.

Livelihoods Recovery

Loss of livelihoods of local fishermen was the greatest impact from the tsunami wave in Yemen. Compensation and assistance to fishermen in the affected areas to replace their fishing gear and rebuild their fishing facilities is critical for them to recover and resume a normal life. Estimates of these losses are in the range of $2 million.

Tourism Recovery

Tourism in the affected areas is still limited, even though the potential for development is very high, specifically in Socotra. Support to local authorities to develop sustainable eco-tourism is recommended. Tourism could help local fisher communities to find alternative incomes other than fishing, which provides the main source of subsistence.

Integrated Coastal Zone Management

In the affected sites, Socotra provides a good example of adopting coastal zone management. This model and experience in developing such zoning plans should be transferred to other sites. Training and assistance to Yemeni authorities in coastal zone management is highly recommended.

Early Warning

The current capacity for early warning should be assessed. Based on the outcome of the assessment, Yemen should be assisted to establish an integrated national early warning system to be coordinated by the Ministry of Water Resources and Environment. Such a system should be able to address the various aspects of early warning, not only for tsunamis, but also other issues of concern such as flash floods.

Yemen should be integrated into regional early warning systems to be developed and be involved in regional coordination processes. As a part of this, a network for monitoring of environmental parameters of concern should be established in the country.

Risk Assessment

Risk mapping should be undertaken for all possible environmental emergencies, followed by dissemination of risk maps and information to decision makers, the general public and communities at risk in appropriate formats. Further study is required on development of indicators and provision of statistical information on the occurrence of environmental emergencies. Documentation and sharing of information on risk management between affected countries would be helpful.

Disaster Management

Support should be given to the Yemeni authorities in the preparation of national plans for the protection of coastal areas from natural disasters. Support should be given in capacity building and strengthening the Environmental Emergency Unit in the Ministry of Water and Environment to undertake its mandate. In addition, there is a need to carry out a full assessment of potential hazards and to strengthen coordination between the EEU and local level actors (local governments and communities). The local rural development projects, the Fisheries Association, and other local actors offer an opportunity for developing local level platforms for environmental emergencies management.

The CDC mentioned above is responsible for disaster management but was not able to respond to the tsunami disaster in the country. However, it has communication and mobilization capability and can assist during environmental emergencies if properly guided. UNDP has been working with the Government of Yemen to strengthen the CDC. Yemen also has a vibrant media (local TV, satellite TV, radio) that is fully accessible. Cell phones also have a wide coverage and could be used for communication during or after emergencies. Communities need to develop a culture of safety and resilience, through information management and exchange, education and training, research and public awareness.

Key activities needed include developing a strong legal and policy framework, assessing available resources and developing strategies for resource mobilization, and promoting community participation.

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SOMALIA



Hafun, Somalia (8 January 2005). A Somali man walks through debris on the island of Hafun, the worst hit area in Somalia. Almost all its 4,500 inhabitants were made homeless. © Francesco Broli/World Food Programme/ Reuters



8. NATIONAL RAPID ENVIRONMENTAL DESK ASSESSMENT – SOMALIA

8.1 Introduction

Approximately 650 kilometres of the Somali coastline was impacted by the tsunami, primarily in the stretch between Xaafun (Hafun) (Bari region) and Garacad (Mudung region), with differing degrees of devastation. The tsunami resulted in the death of some 300 people and extensive destruction of shelters, houses and water sources as well as fishing gear. The tsunami came at a time when many parts of the country were beginning to recover from four years of consecutive drought and periodic floods in addition to chronic insecurity. The impact of the tsunami therefore posed a further assault to an already vulnerable population.

The livelihoods of many people residing in towns and small villages along the Somalia coastline, particularly in the northern regions, were devastated. About 18,000 households were estimated to be directly affected and in need of urgent humanitarian assistance. The tsunami disaster coincided with the peak of the fishing season which increased the number of those affected.

The immediate response by UN agencies and other organizations has focused on meeting the life saving needs of the affected population such as emergency food, medicines and non-food items. These were dispatched less than two days after the crisis started unfolding, whereby clean drinking water, shelter and non-food items were urgently needed because most of the wells had been submerged and contaminated by seawater and other debris whilst food items had been washed away. UN agencies, including UNDP, WFP, UNHCR, and OCHA as well as NGOs fielded a multi-agency assessment mission to the areas affected by the tsunami. Specifically, WFP, UNICEF, UNHCR and WHO have either pre-positioned or distributed relief items to some of the affected areas including food, medicines and emergency relief kits.



Hafun, Somalia (31 December 2004). Aerial view of the aftermath of the tsunami that struck Harun, Somalia on 26 December. The tsunami killed more than 300 people and destroyed homes, boats and fishing equipment. About 18,000 households were estimated to be directly affected and in need of urgent humanitarian assistance. © AFP/Getty Images

8.2 Overview of the Environmental Response

On 17 January 2005, UNEP received an urgent request from the Ministry of Fisheries, Ports and Marine Transport of the Government of Puntland to assess environmental damage including habitat destruction, pollution and soil erosion in the affected coastal areas, as well as on Hafun Island, and to ensure environmental considerations are integrated within the recovery and reconstruction process.

In response to the request, UNEP held discussions with the Hon. Mohamed Osman Maye, Minister of Environment and Disaster Management of the Transitional Federal Government of Somalia. During the discussions, it was agreed that UNEP should send a fact finding mission to some of the areas affected by the tsunami, namely Xaafun (Hafun), Eyl, Bandarbeyla and Garacad. UNEP established a team of experts and made arrangements to travel to these areas on 7 February 2005. However, the mission could not be undertaken due to the security conditions in those areas. Consequently, this initial desk report has been prepared using information provided by some United Nations agencies and Non Governmental Organizations (NGOs) as well as from various independent sources. In addition, UNEP held a meeting on 17 February 2005 in Cairo, Egypt on Coastal Zone Rehabilitation Management for the Tsunami Affected Region. The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) hosted this meeting in conjunction with the UNEP Asian Tsunami Disaster Task Force and the UNEP Global Programme of Action (GPA). The purpose of the meeting, which involved the tsunami affected country focal points of Regional Seas and Experts, was to discuss at the highest possible political/institutional level, basic principles for coastal reconstruction and rehabilitation within the broader framework of integrated coastal zone management and to provide information on related policy tools and mechanisms aimed at reducing impacts of possible future disasters. Also, the meeting served as a forum for exchanging knowledge and fostering linkages between responsible national institutions to further enhance cooperation among the affected countries.

8.3 Preliminary Findings: Impact on Natural Resources

Since 1991, Somalia has been subjected to extreme environmental degradation both natural and man-made associated with the current war and lawlessness. The affected areas included Lower and Middle Shabelle, Lower Juba, Bay, Bakool and Puntland. Other areas can be identified through closer inquiry.

There is a growing danger of deterioration of the environment and personal health. The economic crisis, high population pressure, competition over limited resources and poverty are root causes leading to hundreds of thousands of Somali people destroying the fragile ecosystems and misusing resources they depend upon for their survival and well-being.

Among other things, the challenges facing Somalia today are growing deterioration of forest land, desertification and depletion of wildlife. The economic potential of Somalia's marine resources has been seriously affected and threatened, whilst dumping of toxic and harmful waste is rampant in the sea, on the shores and in the hinterland.

Somalia has suffered triple disasters. First, it had been affected by four years of successive drought which displaced many people from their areas of origin. Then their livestock perished in considerable numbers following the drought and finally came the tsunami which devastated homes, roads, other infrastructure and fishing gear. The livelihoods of many people residing in small villages along the coastline, particularly in the northeastern regions were worst affected.

Mangroves and Coastal Vegetation

Although Somalia is not well endowed with natural resources that can be profitably marketed internationally, it has ecosystems that are key to its social and economic development to meet the needs of the population. One of the major ecosystems includes mangroves, which have high productivity levels as they receive nutrients from both sea and land. Mangrove forests are home to a rich assortment of wildlife, such as birds and many aquatic species, but they also provide another crucial and often overlooked service to their ecosystems: they are natural buffers that shelter coastal communities and wildlife from the brunt of storms and waves, such as tsunamis. The patches of mangroves in Somalia play a vital role in reducing shoreline erosion. Also, mangroves perform several other ecological and hydrological functions including water supply, erosion protection and habitats for fish. They are critical for the conservation of biological diversity.

Once common in the Horn of Africa and extreme south of Somalia particularly along the coast from Kismaayo (Chisimayu) to near the border with Kenya, the patches of mangrove forests are now degraded. One of the major factors changing the characteristics of mangroves in Somalia is the over-exploitation for firewood and construction purposes, which leads to more sedimentation and excessive nutrient loads. Somalia depends principally on domestic wood and charcoal to meet its household energy needs. Some areas have been destroyed, with clearing so extreme that no large areas of vegetation have survived, leaving the land barren. The function of the mangroves as coastal buffers and the effects of their removal along the coastline may have exacerbated the impacts of the aftermath of the tsunami. The extent of the damage is still not known and it may take some time before the impacts are known since the deposits of silt could clog the pores of the aerial roots of mangroves and suffocate them.

Domestic and foreign demand for forest products is growing. The heavy dependence on wood for firewood and building materials with an increase in charcoal exports to the Middle East has contributed to the destruction of the forests, woodlands, mangroves and the entire natural habitat in Somalia. Currently, there very limited alternative energy sources.

Oil pollution could also be one of the threats to the mangroves as there are tanker lanes along the Somalia coast linking the Gulf to the Atlantic Ocean. In its ports, Somalia lacks the basic facilities for handling bilge, and small oil spills are common.

Overall, the regenerative capacity of the mangrove systems may have declined considerably and the ability to provide fishing grounds for fish, molluscs and crustaceans could have dramatically decreased as a result of uncontrolled harvesting. However, an assessment of the extent of damage to the patches of mangroves and coastal vegetation as well as detailed impacts and risk analysis needs to be undertaken.

Coral Reefs

Somalia has excellent fringing and patches of coral reefs along the Gulf of Aden coastline and southern Somalia near the Kenyan border which are highly biodiverse. The rock-like structure of coral reefs serve as a natural water break; a physical barrier near the ocean's surface that breaks waves offshore and dissipates most of their force before they reach the land. Therefore, they have the capacity to create rigid, wave-resisting structures that modify their physical environment, thus creating a wide variety of associated depositional movements.

The coral reefs have suffered natural disturbances in the past, including those caused by the recent tsunami. The tsunami could have reduced some of the coral reefs to rubble due to the crushing force of the waves. There could also be significant damage to the coral reefs as a result of land runoff of wastes and pollutants, debris, soil and organic matter, particularly, those near the coastal towns of Kismaayo (Chisimayu) and Mogadishu. Due to the absence of appropriate national institutions there are no mechanisms to assess the damage to coral reefs by natural hydrological related disasters and human

Priority Ecosystems and Protected Areas in Somalia



	Total Area km²	Potential Area Impacted km²
Coral Reefs	720	494
Mangroves	906	390
Protected Areas	47,144	NA

website: www unep-wcmc.org

please contact Kaveh Zahedi or Phillip Fox for further details

All data on Protected Areas, Coral Reefs, Seagrasses and Mangroves are available from UNEP-WCMC databases.
Data on population density kindly provided by CIESIN.

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activity and plans for their protection. An assessment of the coral reefs is therefore needed to determine the extent of damage caused by the tsunami and other natural disasters such as El Ni_o as well as general degradation arising from long years of pressure from human activities and management neglect. IUCN is working with local authorities and NGOs to monitor fisheries and establish a protected area in the Saad ed Din Islands.

Surface and groundwater

Surface and groundwater were hard hit by the impacts of the tsunami. Specifically, freshwater bodies and fishery breeding grounds were contaminated with the saline water. Wells located in the coastal areas where seawater has penetrated have become clogged or buried by sand washed in by the giant waves, resulting in brackish and polluted waters. The sea water may have also invaded the porous rocks thus contaminating the underground water with salt. The coastal communities depend on surface and groundwater for survival. This is a serious public health issue because local water sources have been contaminated. The long-term impacts or reversibility of this situation are unknown at this stage. Coastal communities will have to wait for rains to flush out the saline water from the aquifers and the porous rocks that hold the groundwater. It may take years for the rains to cleanse the rocks. An assessment and detailed analysis of surface and groundwater quality is urgently needed and its outcome will serve as a basis for developing appropriate intervention measures.



Hafun, Somalia. Nurto Ibrahim Mudey outside a makeshift house in the village of Hafun, Somalia. Mudey's house was destroyed by the tsunami on 26 December, and she lost her husband and six-month-old son. © Mugo Njeru/Daily Nation

Soils

It is estimated that from 46 to 56 per cent of Somalia's land area can be considered permanent pasture. About 14 per cent is classified as forest and approximately 13 per cent is suitable for cultivation, but most of that area would require additional investments in wells and roads for it to be usable. The remaining land is not economically exploitable. In the highlands around Hargeysa, relatively high rainfall has raised the organic content of the sandy calcareous soils characteristic of the northern plains, and these soils have supported some dry farming. The area between the Jubba and Shabeelle rivers has soils varying from reddish to dark clays, with some alluvial deposits and fine black soil. This is the area of plantation agriculture and subsistence agropastoralism. South of Hargeysa begins the Haud, whose red calcareous soils continue into the Ethiopian Ogaden. These soils support vegetation ideal for camel grazing. To the east of the Haud is the Mudug plain, leading to the Indian Ocean coast; this region, too, supports pastoral grazing. The coastal areas of the Mudung plain were impacted by the tsunami. This may have caused contamination of the soil with sea water.

In general there is soil degradation in Somalia due to poor land use. Degradation is mainly caused by natural phenomena for example drought and floods giving rise to soil erosion which in turn is exacerbated by overgrazing, deforestation (uncontrolled firewood and charcoal production for domestic use and exports) and human population pressures (settlements and refugee and IDP camps). Proper land use and good soil management is therefore key to the development of agriculture in Somalia on which the livelihoods of the majority of the population depend. Assessment of land utilization and management and detailed analysis of impacts of disasters and other activities is crucial.

Marine and Coastal Environment

The coastline of Somalia is 3,898 kilometres long and about 55 per cent of its population lives along this coastline. With an area of continental shelf of 40,392 square kilometres and territorial sea of 68,849 square kilometres, it produces about 900 metric tonnes (1997 estimate) of molluscs and crustaceans and 20,000 metric tonnes (2000 estimate) of marine fish. The coastline consists of patches of swamp and related vegetation which includes mangroves and savannah related vegetation. The coastal and marine environments have been subjected to a variety of pressures including erosion, oil pollution, waste dumps, human settlements and the discharge of municipal waste water due to the lack of proper water and sanitation facilities.

Somali waters have a high potential for fishing. As a result, the Fisheries and Marine Resources Minister has indicated that a study by his ministry had shown a large number of foreign vessels illegally fishing in Somali waters and serious pollution caused by vessels discharging toxic waste. Heavily armed foreign boats have often tried to exploit the breakdown of law and order in Somalia since the overthrow of President Mohammed Siad Barre in 1991 by fishing in the rich Somali waters, thus depriving coastal communities of resources. However, there has not yet been any fish stock assessment undertaken for the country to enhance better management decisions for the efficient utilization of this resource.

8.4 Preliminary Findings: Human Environmental Impacts

Waste

Prior to the civil war, domestic and commercial solid waste in cities was collected and transported for disposal. However, the system of waste collection and disposal eventually collapsed due to lawlessness and lack of proper central government to efficiently manage the system. During the civil war, waste collection services ceased to function and the collection vehicles and equipment were either looted or destroyed. The garbage transfer stations and depots were also damaged. As a result, mountains of waste accumulated, which continue to pose serious human health risks and environmental hazards.

Further, Somalia is one of the many Least Developed Countries that received countless shipments of illegal nuclear and toxic waste dumped along the coastline. Starting from the early 1980s and continuing into the civil war, the hazardous waste dumped along Somalia's coast comprised uranium radioactive waste, lead, cadmium, mercury, industrial, hospital, chemical, leather treatment and other toxic waste. Most of the waste was simply dumped on the beaches in containers and disposable leaking barrels which ranged from small to big tanks without regard to the health of the local population and any environmentally devastating impacts.

The issue of dumping in Somalia is contentious as it raises both legal and moral questions. First, there is a violation of international treaties in the export of hazardous waste to Somalia. Second, it is ethically questionable to negotiate a hazardous waste disposal contract with a country in the midst of a protracted civil war and with a factionalized government that could not sustain a functional legal and proper waste management system.

The impact of the tsunami stirred up hazardous waste deposits on the beaches around North Hobyo (South Mudug) and Warsheik (North of Benadir). Contamination from the waste deposits has thus caused health and environmental problems to the surrounding local fishing communities including contamination of groundwater. Many people in these towns have complained of unusual health problems as a result of the tsunami winds blowing towards inland villages. The health problems include acute respiratory infections, dry heavy coughing and mouth bleeding, abdominal haemorrhages, unusual skin chemical reactions, and sudden death after inhaling toxic materials.
It is important to underscore that since 1998, the Indian Ocean has experienced frequent cyclones and heavy tidal waves in the coastal regions of Somalia. Natural disasters are short-term catastrophes, but the contamination of the environment by radioactive waste can cause serious long-term effects on human health as well as severe impacts on groundwater, soil, agriculture and fisheries for many years. Therefore, the current situation along the Somali coastline poses a very serious environmental hazard, not only in Somalia but also in the eastern Africa sub-region.

Water and Sanitation

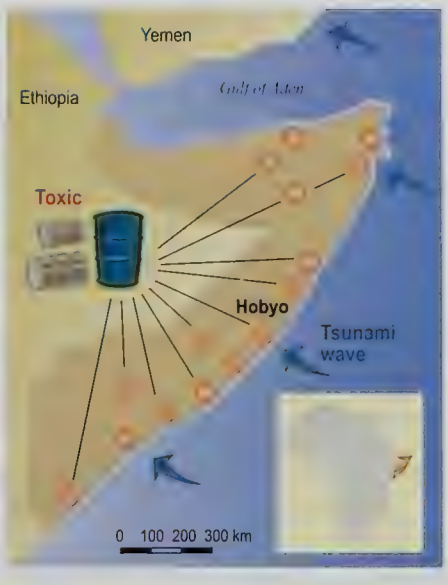
Access to safe water is a significant problem in Somalia, aggravated by the destruction and looting of water supply installations during the civil war, the continued conflict and the general lack of maintenance. This situation is compounded by erratic rainfall patterns that exacerbate both drought and sporadic flooding. It is estimated that 65 per cent of the population does not have reliable access to safe water throughout the year. Less than 50 per cent of Somalis live in households with sanitary means of disposing excreta.

The poor water supply has resulted in communities and families digging independent uncontrolled wells. This has led to the heavy reliance on ground water and risks to human health, resulting from poor sanitation and the total breakdown in solid waste management.
The impact of poor environmental sanitation is particularly felt in the cities, towns and large villages or other places where people live in close proximity to each other. Human and household waste disposal sites are generally close to dwellings and water sources. Lack of garbage collection and prolification of plastic bags has considerably affected the urban environment and water sources. Seepage from the garbage continues to contaminate ground and surface water thereby posing risks to human health and the environment.

There is no information yet available regarding the impacts of the tsunami on local-level water and sanitation infrastructure. However, there is a good probability that groundwater wells may be contaminated with salt. In addition, if the tsunami ruptured or flooded traditional toilets, sewage contamination of groundwater can also be expected, with serious risks to human health. This would be in addition to any background level of contamination that might already exist from poor waste management practices.

Case Study: Hazardous waste dumping in Somalia





Photos courtesy of Minister for Parliamentary Affairs Transitional Federal Government of Somalia (top) and Abdiashid Abdillahi, resident of Indaan, North Hobyo (bottom)

Industrialised countries generate about 90 per cent of the world's hazardous wastes. The amount of waste crossing national frontiers is increasing and is likely to continue, due to the high growth of industries in developed countries accompanied by a high increase in the production of hazardous waste. Some European firms are known to be engaged in the business of dumping hazardous waste in Africa. The primary cause of this is cost. It has been estimated that it costs as little as $2.50 per tonne to dump hazardous waste in Africa as opposed to $250 per tonne in Europe.

During the Somalia civil war, hazardous waste was dumped in the country by industrialized countries. Somalia appeared attractive for hazardous waste dumping due to:

- *Political instability.* Since 1991 Somalia lacked a central government to safeguard its long coastlines and territories.
- *Availability of dumping sites.* There is a general problem of finding suitable dumping sites within the countries generating these wastes as well as high cost of recycling or incinerating. Somalia happens to have abundant sites for dumping waste.
- *Low public awareness.* The public were hardly informed about dumping of wastes in the country. Besides the people were trying to eke their living in the midst of extreme social problems and poverty created by the war.

The impacts of the December 2004 tsunami stirred up hazardous waste deposits on the beaches around North Hobyo causing some health and environmental problems in the area.

8.5 Conclusions and Recommendations

On the basis of this initial desk report, the following conclusions have been made:

1. The tsunami caused some damage to the environment along the coast which may have been exacerbated by previous levels of environmental degradation.

2. A multi-agency mission is needed on the environment to be led by UNEP with broader terms of reference which will include, among others:
 - Assessment of the environmental impacts of the tsunami-affected areas.
 - Assessment of the environmental impacts of drought and flood-affected areas.
 - Assessment of the impacts of toxic and other waste.
 - Exploring possibilities of creating biodiversity protected and/or heritage sites for the Horn of Africa ("Horn of Africa Heritage").

3. The outcome of the mission should include recommendations focusing on short, medium and long term measures covering the following areas: institutional development, development of policy and legislation, awareness raising and capacity-building, land use and soil management (including desertification control), freshwater resources and sanitation, marine and coastal ecosystems management, forest resources and biodiversity (including wildlife conservation), waste management, disaster management (prevention, preparedness, assessment, response and mitigation) and disaster risk reduction.

4. Environmental vulnerability is likely to intensify in Somalia with the incidence of recurrent drought and flood disasters arising from climate variability and climate change. This will have drastic effects on well-intentioned development efforts of the government, local communities and international organizations. Also, it will set back development gains, perpetuate the existing poverty cycle and reduce the chances of attaining the Millennium Development Goals (MDGs).

5. Coping with the aftermath of the tsunami seems to indicate that Somalia lacks the capacity to deal with such disaster events and would therefore need to put in place aggressive programmes to develop and/or strengthen both institutional and human capacities for disaster management.

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ACRONYMS

ADB	Asian Development Bank
ATDTF	UNEP Asian Tsunami Disaster Task Force
AusAID	Australian Agency for International Development
BAKORNAS	National Coordinating Body for Disaster Management, Indonesia
BAPEDALDA	Local Environmental Management Agency, Indonesia
BAPPENAS	National Planning Agency, Indonesia
CCD	Coast Conservation Department
CEA	Central Environmental Authority
CERM	Coastal Environment and Resource Management
CORDIO	Coral Reef Degradation in the Indian Ocean
DEPI	UNEP Division of Policy Implementation
DEWA	UNEP Division of Early Warning Assessment
DPDL	UNEP Division of Policy Development and Law
DTIE	UNEP Division of Technology, Industry and Economics
DRP	District recovery plan
DWLC	Department of Wild Life Conservation
EIA	Environmental impact assessment
FAO	Food and Agriculture Organization
FFI	Fauna and Flora International
GCRMN	Global Coral Reef Monitoring Network
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographical Information System
GNP	Gross National Product
GOI	Government of Indonesia
GOM	Government of Maldives
GOS	Government of Seychelles
GPA	Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
GPS	Global Positioning System
HABITAT	United Nations Human Settlements Programme
ICRAN	International Coral Reef Action Network
ICRC	International Committee for the Red Cross
ICRI	International Coral Reef Initiative
ICZM	Integrated Coastal Zone Management
IDP	Internally Displaced Persons
IETC	UNEP International Environmental Technology Centre
ILO	International Labour Organization
IMO	International Maritime Organization
UCN	The World Conservation Union
JBIC	Japanese Bank for International Cooperation
LTTE	Liberation Tigers of Tamil Eelam
MDG	Millennium Development Goals
MEC	Ministry of Environment and Construction

MENR	Ministry of Environment and Natural Resources
MFE	Ministry of Forestry and Environment
MOD	Ministry of Defence
MoE	Ministry of Environment
MOFOR	Ministry of Fisheries and Oceanic Resources
MOH	Medical Officer of Health
MONRE	Ministry of Natural Resources and Environment
MPA	Marine Protected Area
MPCLG	Ministry of Provincial Councils and Local Governments
NARA	National Aquatic Resources Research and Development Agency
NDRP	National Disaster Response Plan
NGO	Non-Governmental Organization
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PCAU	UNEP Post-Conflict Assessment Unit
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
POSKO	Coordination Post, Indonesia
RCZ	Restricted construction zone
REA	Rapid environmental assessment
ROA	UNEP Regional Office for Africa
ROAP	UNEP Regional Office for Asia and the Pacific, Bangkok
ROWA	UNEP Regional Office for West Asia, Bahrain
SACEP	South Asia Co-operative Environment Programme
SAM	Special Area Management
SEA	Strategic Environmental Assessment
SCMRT-MPA	Seychelles Centre for Marine Research and Technology-Marine Parks Authority
SPHERE	Humanitarian Charter and Minimum Standards in Disaster Response
TAFLOL	Task Force for Logistics and Law and Order
TAFREN	Task Force for Rebuilding the Nation
TAFRER	Task Force for Rescue and Relief
UNDAC	United Nations Disaster Assessment and Coordination
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNDAC	United Nations Disaster Assessment and Coordination Team
UNHCR	United Nations High Commission for Refugees
USGS	United States Geological Survey
WCMC	UNEP World Conservation Monitoring Centre, Cambridge
WFP	World Food Programme
WWF	The Global Conservation Organization
WHO	World Health Organization

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